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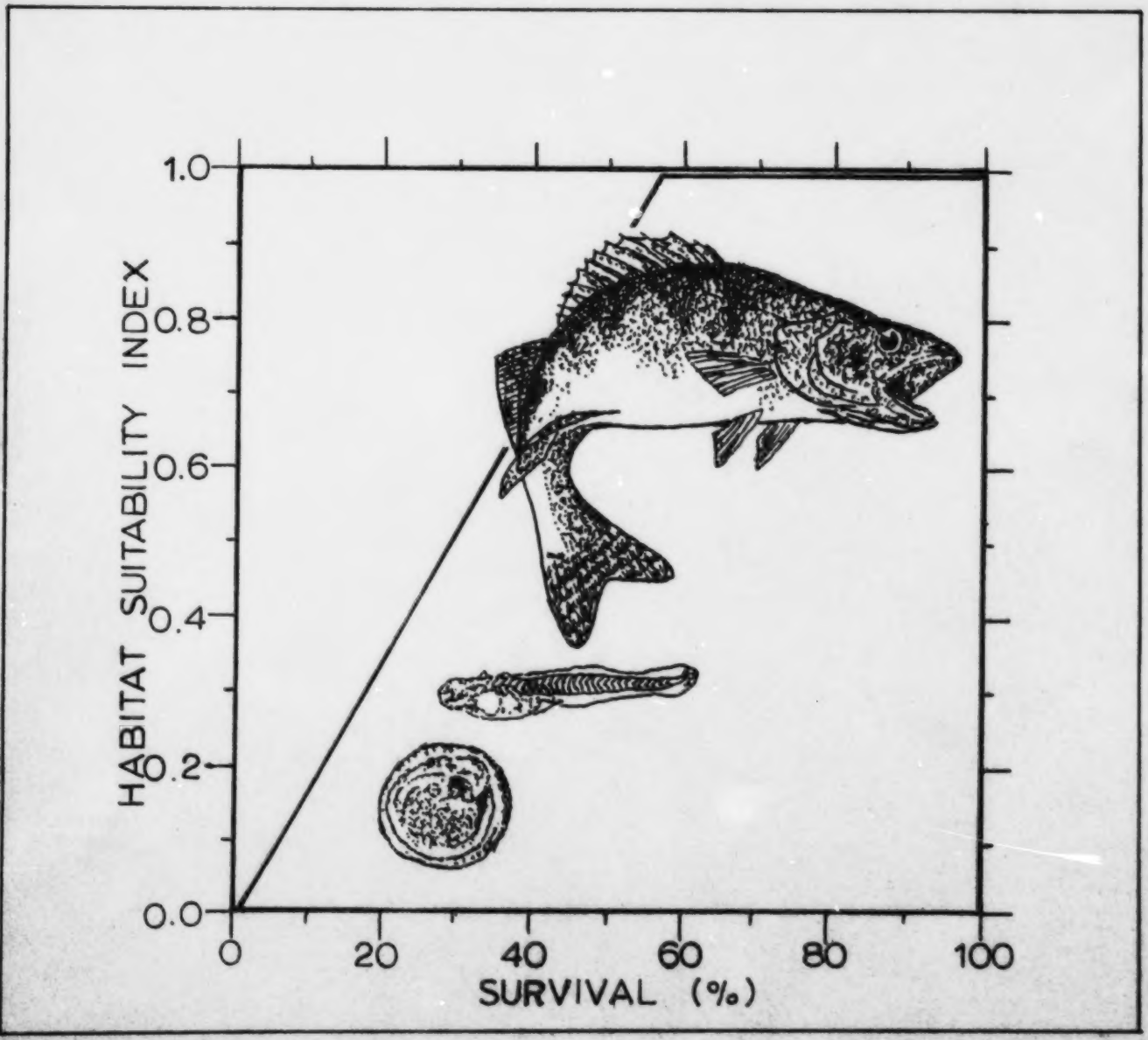
Operation and Evaluation Of Six Saskatchewan Walleye Rearing Ponds 1988

Fisheries Technical Report 88-5



OPERATION AND EVALUATION OF SIX SASKATCHEWAN WALLEYE REARING PONDS, 1988

By

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EXECUTIVE SUMMARY

SITUATION

Management of six Saskatchewan rearing ponds, during the 1988 field season, was aimed at maximizing production of pond reared walleye (Stizostedion v. vitreum) fingerlings. Four of the ponds (Codette, Jackfish, Meadow 1 and Meadow 2) are man made, totally drainable, excavated impoundments with a combined area of 32.8 ha. Glaslyn pond is a totally drainable levee impoundment with an area of 4.0 ha. Shore pond is a semi-drainable, natural pond with an area of 19.0 ha.

Pond management consisted of scheduled fertilization, manipulation of fry stocking densities, optimizing pond water levels, and fingerling harvest. Fertilizers used included several applications of alfalfa pellets totalling 1 400 kg/ha/pond in Codette, Meadow 1 and Meadow 2, and 1 150 kg/ha in Jackfish Pond. Glaslyn and Shore ponds were not fertilized. Superphosphate (11-55-0 granular ammonium phosphate) was applied to Codette Pond at 30 kg/ha in several applications, and to Meadow 1 at 10 kg/ha. Stocking rates were 6 300 fry/ha in Shore Pond, 25 000 fry/ha in Jackfish and Glaslyn ponds, 50 000 fry/ha in Codette and Meadow 1 ponds, and 75 000 in Meadow 2 Pond.

A walleye Habitat Suitability Index (HSI) model was modified for evaluation of Saskatchewan rearing ponds. The ponds were rated on a linear scale of 0.0 (unsuitable) to 1.0 (optimal). The HSI ratings obtained were then compared to the

harvest results.

RESULTS

An estimated 441 500 fingerlings were produced during the 1988 operation. These were stocked in Codette Reservoir (200 000), Smuts Lake (4 800), Martin's Lake (10 500), Turtle Lake (90 000), Attons Lake (7 000), Greig Lake (9 500), Jackfish Lake (24 300), Murray Lake (5 200) and Meadow River (7 000). The remainder were lost to harvest mortality(mainly due to logistical problems encountered at Meadow 2 pond).

The fertilized ponds (Codette, Jackfish, and Meadow 1 and 2) produced 99.5% of the fingerlings. The fertilized ponds received good to excellent HSI ratings, while the unfertilized ponds received poor ratings. The HSI ratings were: Meadow 2, 0.82; Codette, 0.81; Meadow 1, 0.76; Jackfish, 0.66; Glaslyn, 0.42; and Shore, 0.00. A significant correlation ($r = 0.95$, $p \leq 0.05$) exists between pond yield (kg/ha) and HSI rating, but more data are needed to verify the model. The model was able to identify factors limiting production in each of the ponds, some of which can be mitigated by altering the individual pond management plans.

A highly significant correlation ($r = 0.872$; $p \leq 0.01$) was found between fingerling survival and the mean weekly usable zooplankton concentration. According to the regression, good fingerling survival (> 30%) appears to be at usable zooplankton numbers >130 zooplankters/L. The strong correlation suggests the

importance of high zooplankton abundance for pond culture success. In order to achieve these levels of zooplankton production, the rearing ponds must be fertilized.

Pond fertilization is limited by cost and the time required to handle large quantities of fertilizer, and by the effects on the pond water quality. Water quality data from Meadow Lake ponds indicate that the present pond fertilization practice had limited impact on the overall water quality of the Meadow River.

A negative correlation ($r = -0.86$) between the mean weekly un-ionized ammonia concentration and fingerling survival was found to be highly significant ($p \leq 0.01$). In this regression, total mortality is at a mean weekly un-ionized ammonia concentration of 0.19 mg/L.

Both of these correlations were used to generate suitability index curves which were used in calculating some of the life requisites of the HSI model.

Recommendations are provided for the 1989 pond operation.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

Six walleye rearing ponds located in central Saskatchewan were operated in 1988. Management of these ponds was aimed at maximizing production of pond reared walleye (Stizostedion vitreum vitreum) fingerlings. The ponds were constructed and operated with assistance from the Fish and Wildlife Development Fund (FWDF). The fish enhancement projects involved include: Codette, Meadow 1, Meadow 2, Jackfish, Glaslyn and Shore rearing ponds. Background information for these ponds is detailed in Arsenault (1987a) and Liaw (1984, 1987).

Management practices used include: pond fertilization, water level manipulation, aeration (excluding Glaslyn and Shore), stocking density variation, timing of stocking (corresponding to high forage levels), and timing of harvesting fingerlings (to coincide with maximum use of forage levels balanced with maximum return of fingerling numbers).

The purpose of this report was to evaluate pond performance using the lacustrine version of a Walleye Habitat Suitablility Index (HSI) model (McMahon et al.1984). The model was modified to evaluate Saskatchewan rearing ponds and was structured to produce an index of walleye habitat quality between 0.0 (unsuitable) and 1.0 (optimum).

2. PROCEDURES

2.1 THE REARING PONDS

Codette Pond is a totally drainable excavated

impoundment adjacent to the south shore of Codette Reservoir. The pond was constructed by the Saskatchewan Power Corporation in 1985. and was operated for the third season in 1988.

The Meadow Lake ponds are also totally drainable excavated impoundments, constructed in the fall of 1986. They were operated for the second season in 1988. They are located at the east side of the Meadow Lake town site, adjacent to the town water treatment ponds. The ponds drain into their respective catch ponds. Here the fingerlings are concentrated while the pond water passes through screened outlets into a channel leading to the Meadow River. The fingerlings are collected and then transported to nearby lakes.

Jackfish and Glaslyn ponds are also totally drainable but utilize mainly dike work across a slope to impound water. Jackfish Pond is a cooperative Fish Enhancement project between the Battlefords Wildlife Federation (BWF) and Fisheries Branch. It was constructed in 1984, and operated for the fourth time in 1988. Glaslyn Pond was constructed by the Turtle River Wildlife Federation in 1986 and is also a cooperative Fish Enhancement project. It is located adjacent to Curry Lake (6 km east of Glaslyn) and was operated for the third season in 1988.

Shore Pond is a semi-drainable, natural waterbody adjacent to the east shore of Delaronde Lake. It has been in operation since 1981 with the exception of 1987.

Morphometric maps of the ponds can be found in Appendices 1 to 5. Location and morphometry of the ponds at FSL are listed in Table 1.

Table 1. Location and morphometry of Saskatchewan walleye rearing ponds at FSL.

Pond	Location	Area (ha)	Volume ($10^3 m^3$)	Depth (m) mean	max.
Codette	20-49-17-W2	10.0	200.0	2.0	2.2
Jackfish	9-48-17-W3	13.0	176.0	1.4	2.3
Meadow 1	25-59-17-W3	6.2	117.9	1.9	2.5
Meadow 2	25-59-17-W3	3.6	70.3	1.95	2.5
Glaslyn	10-51-16-W3	4.0	34.6	0.86	2.5
Shore	23-57-7-W3	19.0	254.0	1.3	2.0

2.2 POND FERTILIZATION

Table 2 shows the fertilization rates used in 1988. No fertilizer was applied to either Glaslyn or Shore pond. Square alfalfa hay bales were spread on the respective ponds in March, prior to spring thaw. Two weeks prior to stocking fry, alfalfa pellets were applied to the respective ponds at a rate of 400 kg/ha. One week prior to stocking, pellets were again applied to Codette and Jackfish ponds at a rate of 250 kg/ha, and to the Meadow Lake ponds at a rate of 400 kg/ha. Two additional applications of pellets were given to the ponds within three weeks after stocking, as required.

In addition, granular ammonium phosphate (11-55-0) was applied to Codette and Meadow 1 at a rate of 10 kg/ha, two weeks before stocking. Four additional applications of the superphosphate were applied to Codette Pond at weekly intervals in conjunction with the pellet applications.

2.3 FRY STOCKING

Packing, shipping and stocking procedures were those followed by the Provincial Fish Culture Station at Fort Qu'Appelle. Fry enumeration was done for all ponds by the von Bayer method (volumetric estimation of eyed eggs) as described by Nielsen and Johnson (1983) for all ponds. Enumeration was done by hatchery staff.

Fry were transported in 23 L polyethylene cubitainers

Table 2. Pond fertilization rates, 1988.

Pond	Square Alflalfa Hay Bales (no./ha)	Alfalfa Pellets (kg/ha)	Superphosphate (11-55-0) (kg/ha)
Codette	15	1400	30
Jackfish	-	1150	-
Meadow 1	15	1400	10
Meadow 2	15	1400	-
Glaslyn	-	-	-
Shore	-	-	-

which were filled to about two-thirds with oxygen-saturated water. The remaining one-third of the container was filled with oxygen and securely closed. The cubitainers were loaded into a vehicle and covered with some ice (to slow warming) and a tarpaulin to keep the fry in a dark, cool condition while in transport. Upon arrival at the pond site, water temperatures of both the containers and the pond were checked. The fry were tempered in the closed containers by floating them in the pond water. The containers were rotated frequently to prevent fry from crowding into the corners and suffocating. At the same time, small amounts of water (from the receiving pond) were introduced. About 25 000 to 50 000 fry (1-4 days old) were transported in each container. All ponds were stocked with fry raised at the Fish Culture Station. Stocking rates for 1988 are presented in Table 3. The source of fry was Diefenbaker Lake.

2.4 PHYSIOCHEMICAL MONITORING

Dissolved oxygen (DO) and temperature profiles were measured with a YSI oxygen meter as frequently as possible, usually at each pond visit. Ammonia and pH levels were measured using Hach kits. Transparency of water was measured with a Secchi disc. Pond water levels were recorded at the same visit. Visits were usually at weekly intervals.

Water samples for water quality and bacteriological analyses were collected from the Meadow Lake ponds and their receiving water body (Meadow River) prior to and near the end

Table 3. Stocking rates used in walleye rearing ponds, 1988.

Pond	Date Stocked	Number Stocked	Stocking Rate (no./ha)
Codette	27 May 88	500,000	50,000
Jackfish	25 May 88	325,000	25,000
Meadow 1	25 May 88	310,000*	50,000
Meadow 2	25 May 88	270,000	75,000
Glaslyn	25 May 88	100,000	25,000
Shore	27 May 88	120,000	6,300

*One of the cubitainers of fry lost its oxygen in transport, all fry died. They were replaced the following day by another cubitainer containing approximately 50,000 fry.

of pond drawdown. The samples were immediately placed in coolers, chilled with ice and shipped to the Provincial Laboratory, Department of Health, for analyses.

2.5 BIOLOGICAL SAMPLING

2.5.1 Plankton

Surface plankton samples were taken prior to first pond fertilization and weekly thereafter, until the end of June. Zooplankton samples were generally collected during late morning or early afternoon. The samples were concentrated by filtering 100 L of pond water through a plankton net made of No. 20 bolting silk (80 µm mesh) using a calibrated 10-L plastic pail. Five open water and five inshore locations were sampled. One 100-L plankton sample per pond visit was obtained and preserved in 5% formalin. Zooplankters in the samples were identified and enumerated using a Sedgewick-Rafter cell. The concentrations of the various copepods (including nauplii), cladocerans and Chaoborus were recorded.

2.5.2 Fingerlings

Walleye fingerlings were sampled several times during the growing season with seine and trapnets. Sampling was done on a weekly basis beginning two weeks after stocking. Samples were preserved in 10% formalin for subsequent laboratory analyses.

Total lengths (measured to the nearest 0.5 mm) of at least 50 fish, and average weight (bulk weight of sample divided by sample size) were measured at the laboratory immediately upon arrival.

Stomach contents were determined by analyzing 30-45 fingerlings from each sample. All prey organisms were identified to family (or genus where possible).

2.5.3 Pond Conditions

Water samples were taken at the end of June for determination of total dissolved solids (TDS). At the same time, sediment samples were taken to determine percent organic content by weight. The sediment samples were analyzed using methods described in Brower and Zar (1984).

Percent cover was measured by a point sampling technique as follows: a white Secchi disc was submerged 1 m at 50 random locations in a pond. If vegetation covered any portion of the disk, that point was given a value of one. If no vegetation covered the disk, that point was given a value of zero. Two replicates were carried out. This procedure was done twice on each pond, once in late June and once in early July. The results were averaged and expressed as a percent cover. Cover provide by any other source (eg. rocks, brush piles, etc.) was estimated by eye after pond drawdown. The amount was added to the vegetation cover estimate.

Chlorophyll *a* samples were taken to aid in the determination of pond trophic status. One or two 500-1000 mL

water samples were taken at monthly intervals starting at the time of fry stocking and filtered through glass fibre filters, in the field. The samples were frozen until analysis could be carried out.

2.6 FINGERLING ENUMERATION AND HARVESTING PROCEDURES

Population estimation of cultured fingerlings in Codette Pond was done using a mark-recapture method described in Ricker (1975). Trapnets were used to catch sufficient walleye for marking (Jensen 1981). These traps were set both within the pond, and outside at the pond outlet (the water control gate was opened enough to capture a few hundred walleye at a time, and then closed). Fingerlings were kept in tubs of pond water and slightly immobilized with tricane methane-sulfonate (MS 222), while marking. Clipping of the left pelvic fin was used for a mark. The short term effects of finclipping are considered negligible (Arsenault 1987a, Liaw 1984, Campbell and Rowes 1980). All marked fish were returned to the pond (at several locations) to allow the marked and unmarked fingerling populations to mix. Sufficient numbers (for population estimation) of fingerlings were again captured and checked for marks, during the course of pond drawdown. A population estimate was obtained using the adjusted Petersen method (Ricker 1975). Some of the fingerlings were collected and transported to Martin's Lake and Smuts Lake, while the remainder were released into Codette Reservoir via the control gate. Transportation of

fingerlings to the other lakes was by 450 L distribution tanks supplied with oxygen.

A population estimate for Jackfish Pond was carried out in similar fashion to Codette Pond. Some fingerlings were hauled by distribution tank and stocked directly into Murray Lake. The remainder of the fingerlings were released directly to Jackfish Lake via the water control gate.

Population estimates for the Meadow Lake ponds were made by weighing several subsamples of the fingerling population of each pond in order to obtain an average number of fish per unit weight. Once an average number of fish per unit weight was established, a total weight of fish produced was measured by bulk weighing the walleye as they were released from the rearing ponds. The fingerlings were then transported to the receiving lakes (Turtle Lake, Greig Lake, Attons Lake) and released. In addition, the mark/recapture method was used in Meadow 1 to evaluate the accuracy of the weighing method. Estimates by both methods were the same.

Population estimates for Shore and Glaslyn ponds were done by direct counting as the fish were released.

2.7 ANALYTICAL PROCEDURES

2.7.1 Model Applicability

The lacusterine version of the Walleye Habitat Suitability Index (HSI) Model (McMahon et al. 1984) was modified

to produce a model that is applicable to Saskatchewan walleye rearing ponds. The model provides an index for a lacustrine (rearing pond) habitat based on its ability to support walleye from the larval to 8 cm fingerling stage (60-80 growing days).

2.7.2 Model Description and Assumptions

The model is structured to produce an index of walleye habitat quality between 0.0 (unsuitable) and 1.0 (optimum). Habitat variables believed to be important in limiting abundance and survival of walleye fingerlings are included in this model. Walleye habitat quality is represented by food, cover, water quality and trophic class in this model. Reproductive requirements are not considered, as the model is restricted to the walleye fry, juvenile and fingerling life stages. Variables that are thought to be direct or indirect measures of the relative ability of a habitat to meet these requirements are included in the appropriate component. It should be noted that not all variables that potentially affect walleye populations are included in this model. McMahon et al. (1984) provides a more comprehensive presentation of the model assumptions.

The structure of the rearing pond HSI model for walleye is presented graphically in Figure 1.

Food Component. Average Secchi disk depth (V_1) is considered part of the food component because feeding activity is related to transparency (light) conditions as described by McMahon et al. (1984).

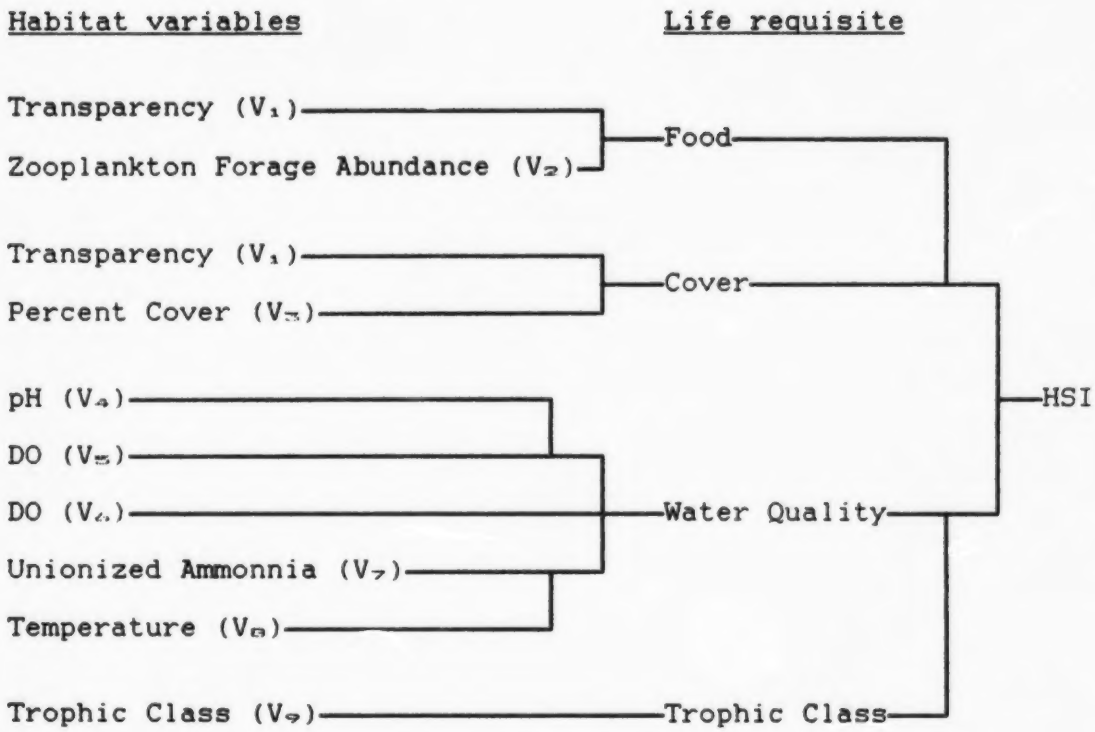


Figure 1. Tree diagram illustrating relationships between model variables, model components, and HSI for walleye in rearing ponds.

The relative abundance of zooplankton forage (V_3) was included in this component because growth, food consumption, and standing crop of walleye are related to forage abundance. The index of relative abundance was measured in no./L usable zooplankton, after Li and Mathias (1982), Arsenault (1987a and b) and Liaw (1987).

As in the original model, the food component variables (V_1 and V_2) are assumed to be direct measures of food availability. Therefore, an increase in the suitability of either food component variable is assumed to increase the amount of available food by the same amount, regardless of the other food component variable rating (McMahon et al. 1984). This assumption is expressed by combining variables through a simple arithmetic mean.

Cover Component. The cover component remains unchanged from the original HSI model by McMahon et al. (1984).

Water Quality Component. The pH (V_4), minimum dissolved oxygen level above the thermocline (V_5), minimum dissolved oxygen at the surface (V_6), un-ionized ammonia (V_7), and temperature (V_8), are included because these water quality parameters affect growth, survival, and/or feeding in walleye. The thermocline definition used in this model is a 1°C reduction of water temperature through a 1 m interval (moving from the surface down). The un-ionized ammonia concentration was added to the model because a strong correlation was found with fingerling survival, as presented in the results and

discussion sections of this report. Boyd (1982) provides a description of the effects of un-ionized ammonia toxicity on fish species.

Trophic Status. A measure of the trophic status of a pond (V_9) is assumed to be a general determinant of habitat suitability for walleye because abundance of walleye often has been related to trophic conditions (McMahon et al. 1984). To increase the accuracy of the trophic status definition the following measures were used: 1) Primary production rate (Chl a mg/m^3); 2) Organic matter in sediments (% dry weight); and 3) Secchi disc transparency (m). The actual parameter levels used to classify the pond trophic status are presented below:

	TROPHIC STATUS		
PARAMETER	(0 - 1) Oligotrophic	(1 - 2) Mesotrophic	(2 - 3) Eutrophic
Primary Production Rate (Chl a mg/m^3)	< 2.5	2.5 - 5.0	> 5.0
Organic matter in sediments (% dry weight)	< 16	16 - 30	> 30
Transparency (Secchi depth)	> 2.0	1.0 - 2.0	< 1.0

2.8 MODEL RELATIONSHIPS

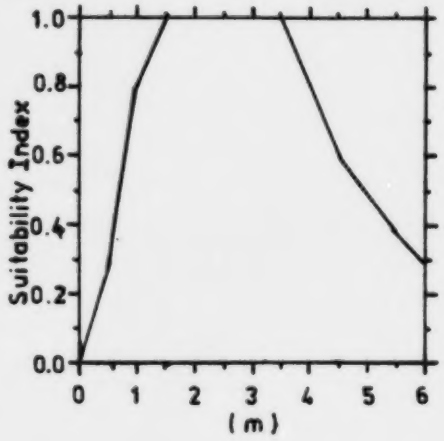
2.8.1 Variable Definitions and Suitability Index Curves

Determination of the HSI for each pond was based on the following variables and their associated suitability index curves:

Variable Definitions and Suitability Index Curves

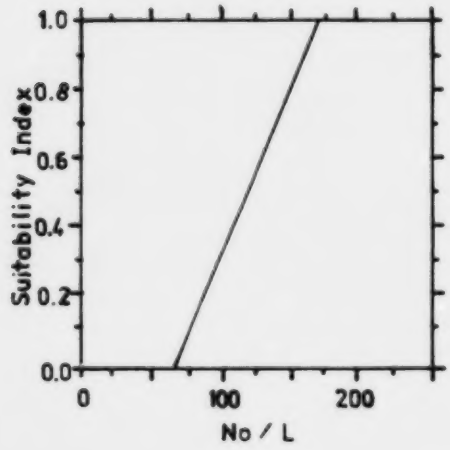
Variable Definition	Suitability Graph

V_1 Average transparency (Secchi depth) during summer. (from McMahon et al. 1984)

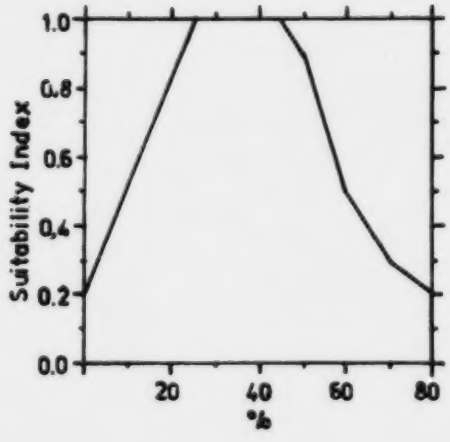


V_2 Relative abundance of zooplankton forage during spring and early summer.

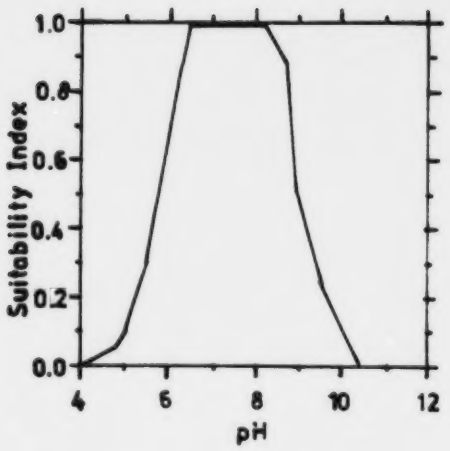
(mean weekly zooplankton concentration - of copepods + *Daphnia* + *Chaoborus* - during pond culture; ie. from late May through the end of June)



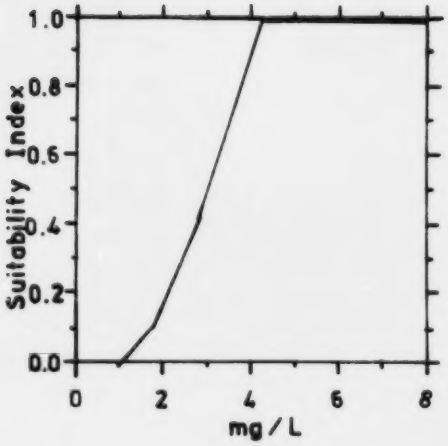
V_3 Percent of water body with cover (boulders, submerged vegetation) and adequate dissolved oxygen (> 3 mg/L) during spring and summer. (From McMahon et al. 1984)



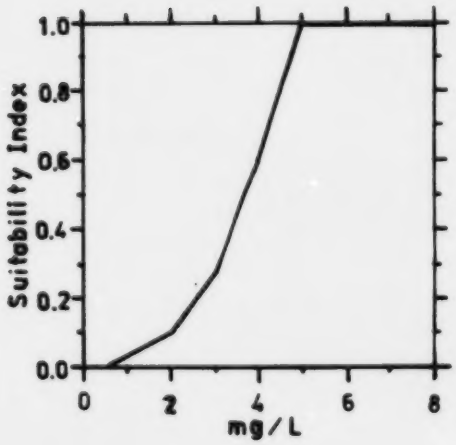
V_4 Least suitable pH during pond culture period. (from McMahon et al. 1984)



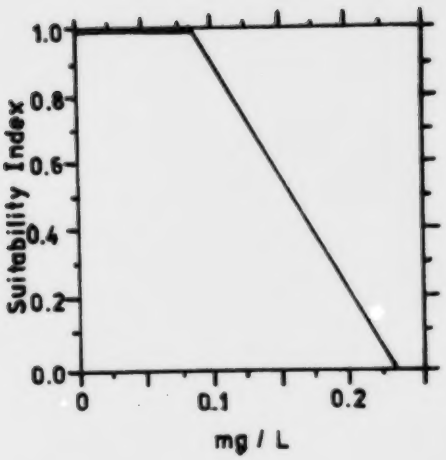
V_5 Minimum dissolved oxygen level above thermocline in summer. (from McMahon et al. 1984)



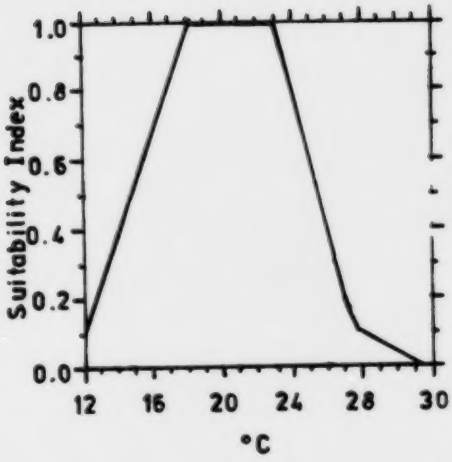
V_6 Minimum dissolved oxygen at surface during summer. (from McMahon et al. 1984)



V_7 Mean weekly un-ionized ammonia concentration during pond culture period.

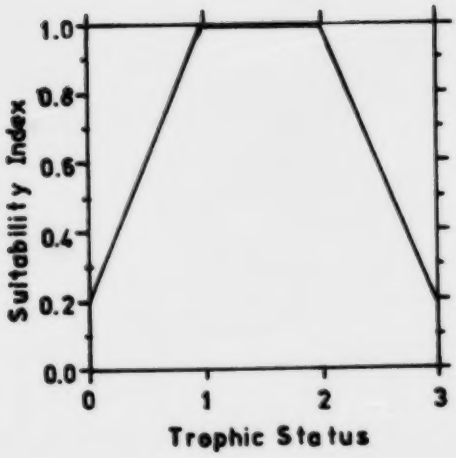


V_8 Mean weekly surface water temperature during spring and summer. (from McMahon et al. 1984)



V_9 Trophic status of pond. (from McMahon et al. 1984)

NB This curve is based on the list of parameters tabled at the end of section 2.7.2. (adapted from Leach et al. 1977)



2.8.2 HSI Equations for Calculating HSI

This model utilizes the life requisite approach and consists of four components: Food, Cover, Water Quality, and Trophic Status.

HSI Calculation. The HSI was defined as the minimum value for any component SI because "suboptimum" conditions for a component were assumed to represent conditions that have measurable negative impacts on individuals and thus limit carrying capacity even when other conditions are optimum (McMahon et al. 1984). The equations used (McMahon et al. 1984) are as follows:

Food (C_F) = $\frac{V_1 + V_2}{2}$

Cover (C_C) = $\frac{3V_1 + V_2}{4}$ when Secchi transparency is ≤3.4 m

Water Quality (C_{WQ}) = lowest of: V_4, V_5, V_6, V_7, V_8

Trophic Status (C_{TS}) = V_9

HSI = the lowest of C_F, C_C, C_{WQ}, or C_{TS}

3. RESULTS

3.1 LIMNOLOGICAL OBSERVATIONS

3.1.1 Water Temperature, DO, pH and Un-ionized Ammonia

Table 4 presents the ranges and means of pond water temperature, daytime dissolved oxygen, pH, and un-ionized ammonia. The mean pond temperatures were all within the 18-24°C range recommended for intensive walleye culture (Krise and Meade 1986), and in the case of Codette pond was very close to the 22°C optimum temperature for juvenile walleye growth determined by Hokanson and Koenst (1986) under laboratory conditions. Pond temperatures at the time of stocking were very close to the mean pond temperatures for the 1988 growing season.

Dissolved oxygen levels were adequate in the ponds throughout the culture period. A persistent hot period in early June reduced oxygen levels to their lowest recorded levels for the growing period. In Meadow 1 and Jackfish ponds, the oxygen levels approached the critical threshold (3.0 mg/L) determined by Stickney (1986). A power failure had turned off the aeration system at Jackfish pond during the same period.

All ponds were alkaline, falling within a 7.9 to 9.2 pH range. The pH in Shore pond was for the most part above the typical pH range determined for walleye (6.0 to 9.0) (Stickney 1986). Fish outside of this range generally have a slowed growth rate and in the extreme case die (Boyd 1982).

Table 4. Surface water temperature, dissolved oxygen, pH and un-ionized ammonia in rearing ponds: May to mid-July, 1988 (Number of measurements taken is in brackets).

Pond	Stocking Temp. (°C)	Surface Water Temperature °C	
		Range	Mean
Codette	19.0	19.0-24.5	21.2 (11)
Jackfish	18.5	17.0-19.0	18.3 (9)
Meadow 1	18.0	16.5-23.0	18.6 (10)
Meadow 2	17.5	16.0-23.0	18.2 (10)
Glaslyn	18.0	17.5-21.5	18.8 (7)
Shore	19.5	18.5-20.5	19.5 (4)

Pond	Daytime Surface DO (mg/L)		DO (mg/L) Above Thermocline	
	Range	Mean	Range	Mean
Codette	5.2- 8.7	7.0 (10)	4.3- 8.1	5.2 (10)
Jackfish	4.0-10.1	7.6 (9)	3.8- 9.8	6.4 (9)
Meadow 1	4.6- 8.6	7.2 (8)	3.6-15.0	6.8 (10)
Meadow 2	6.2-11.6	8.4 (8)	4.0-13.3	6.7 (10)
Glaslyn	5.4-11.0	8.0 (5)	4.8- 9.6	7.3 (5)
Shore	9.1-14.6	11.3 (4)	9.0-14.6	11.7 (3)

Pond	pH		Un-ionized Ammonia (mg/L)	
	Range	Mean	Range	Mean
Codette	7.9-8.7	8.25 (10)	0.02-0.09	0.039 (8)
Jackfish	8.1-8.7	8.45 (8)	0.05-0.17	0.094 (8)
Meadow 1	7.9-8.5	8.23 (7)	0.04-0.09	0.074 (7)
Meadow 2	8.1-8.7	8.38 (7)	0.05-0.16	0.078 (7)
Glaslyn	8.0-8.7	8.42 (5)	0.08-0.24	0.135 (5)
Shore	8.5-9.2	9.05 (3)	0.12-0.28	0.225 (3)

Un-ionized ammonia levels varied greatly between the ponds. The highest levels recorded were in Glaslyn and Shore Ponds (Table 4). These ponds coincidentally had the highest mean un-ionized ammonia levels for the 1988 culture period. A negative correlation ($r = -0.86$, $df = 7$) between the mean weekly un-ionized ammonia concentration (mg/L) and fingerling survival (%) was found to be highly significant ($p \leq 0.01$). Both 1987 and 1988 data were used. The resulting regression line (Fig. 2) is the basis of the SI curve (in section 2.8.1) used to calculate V_4 of the HSI model. Two points (M1 87 and G 87) are excluded from the regression. In these two ponds, low fingerling survival (despite the presence of a low un-ionized ammonia concentration) was a result of pike predation in Meadow 1 (1987) and low oxygen levels in Glaslyn pond (1987).

3.1.2 Water Quality

As in 1987, the Saskatchewan Department of Environment and Public Safety required monitoring of certain water quality variables, to assess the impact of releasing Meadow Lake rearing pond water to the Meadow River. The Meadow River is the source of the town water supply. All samples were analyzed by the Saskatchewan Provincial Lab. The data are presented in Appendices 6 - 8.

Analyses of the water samples indicate that both rearing pond cells had similar or somewhat higher concentrations of chemical substances and nutrients than the receiving water

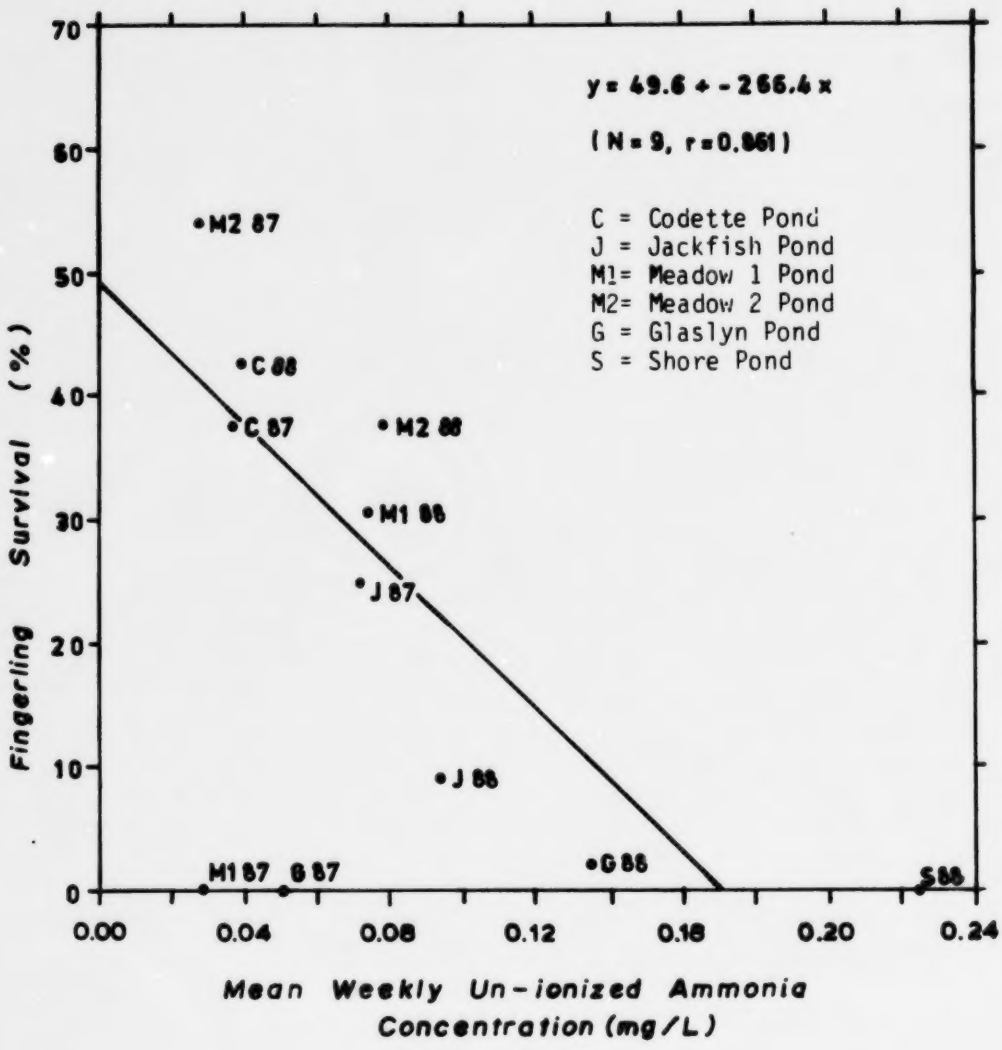


Figure 2. Relationship between mean un-ionized ammonia Concentration and fingerling survival in the rearing ponds, 1987 - 88.

body, especially with respect to magnesium, sodium, chloride, sulphate, Kjeldahl nitrogen, nitrate, suspended solids, TDS and BOD. This is likely due to the response of bottom sediments to drawdown procedures as well as the stirring of sediments by the aeration systems in each cell.

The effects of pond drawdown were more pronounced just upstream of the drainage canal as opposed to farther upstream at the town water intake.

Bacterial samples were collected, however, the samples were too old to be analyzed by the time they reached the Saskatchewan Provincial Lab.

3.1.3 Primary Production

Table 5 summarizes information used to evaluate the food, cover and trophic status components of the HSI model. The mean weekly Secchi disc depths ranged from 0.95 m in Meadow 2 to 1.76 m in Codette Pond. The percent organic content of the pond sediments was highly variable, ranging from 4.62 % in Codette Pond to 32.42 % in Shore Pond. The chlorophyll *a* concentration (mg/m^3) varied from 1.73 in Codette Pond to 6.95 in Meadow 2. The highest percent cover was found in Jackfish Pond (60 %), which was two to three times as much as in any other pond.

3.1.4 Net-Plankton Standing Crop

Changes in zooplankton standing crop are illustrated

Table 5. Primary production parameters of ponds, 1988.

Pond	Mean Secchi disc depth (m)	Organic Content of sediments (%)	Chl *a* (mg/m^3)	Cover (%)
Codette	1.76	4.62	1.73	20.5
Jackfish	1.33	10.58	1.80	60.0
Meadow 1	1.54	2.86	5.58	20.0
Meadow 2	0.95	11.32	6.95	25.0
Glaslyn	1.05	6.27	5.48	20.0
Shore	1.00	32.42	4.01	30.0

in Appendices 9 to 11. Plankton concentrations were monitored weekly to assess the effects of fertilization on, and abundance of, total and usable walleye forage. In these appended figures, usable zooplankton is equal to the total concentration of copepods (excluding nauplii) + Daphnia + Chaoborus on a particular sample day. Other cladocerans are excluded because they tend to be either ignored or a very minor part of the fingerling diet, as determined by stomach analyses. Total zooplankton is equal to the total concentration of all copepods (including nauplii) + cladocerans + Chaoborus on a particular sample day. Analyses of fingerling stomach contents were used to determine what crustaceans were being utilized. Any large differences between usable and total zooplankton forage is largely a result of size selection by the fingerlings.

Some crustaceans tend to be too small to be energy efficient prey items (eg. Bosmina, copepod nauplii) as discussed by Liaw (1987) and Arsenault (1987b). In Appendices 9 to 11, the large differences between total and usable forage is mainly due to large numbers of copepod nauplii (in all ponds), and Bosmina (in both Meadow Lake Ponds). Other cladocerans identified did not attain high numbers in any of the ponds.

3.2 WALLEYE PREY SELECTION

A positive correlation ($r = 0.87$, $df = 10$) between the mean weekly usable zooplankton concentration (No./L) and fingerling survival (%) was found to be highly significant ($p \leq 0.01$). Usable zooplankton include copepods (excluding

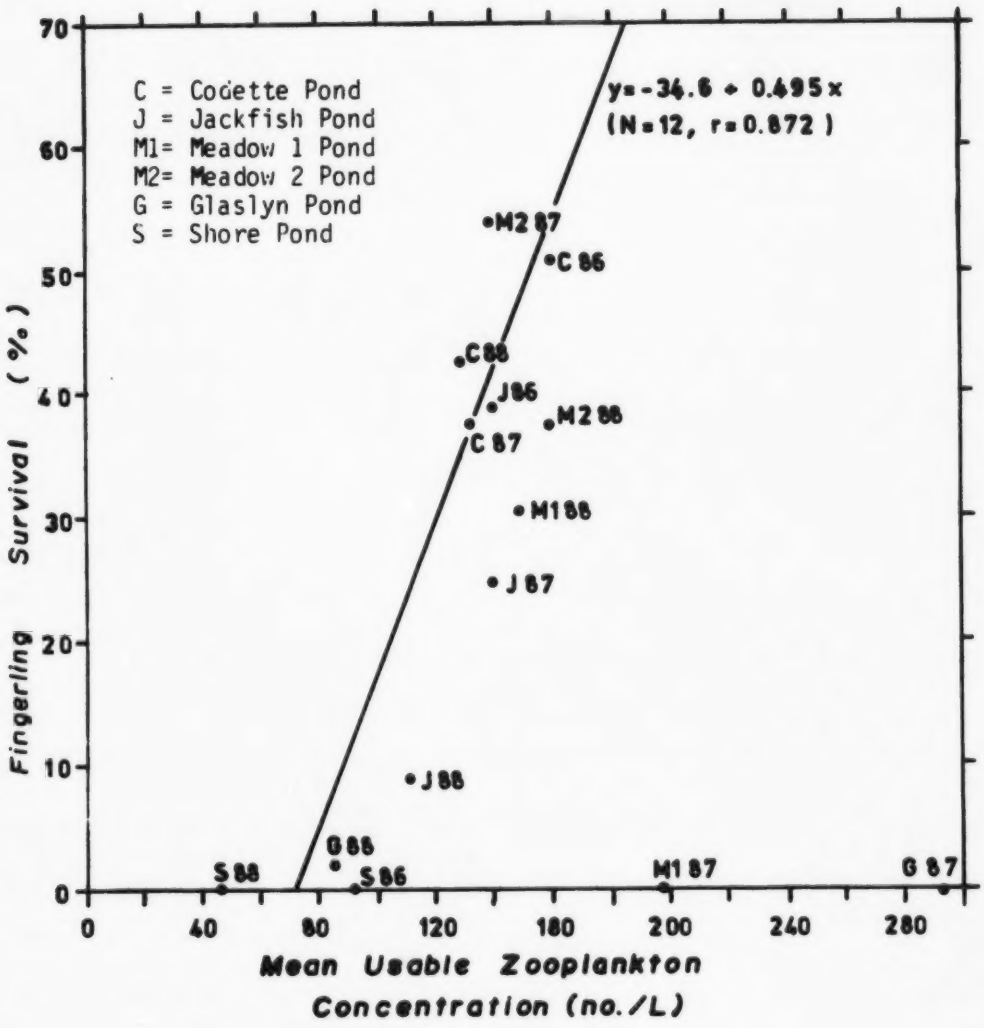


Figure 3. Relationship between mean weekly usable zooplankton concentration and fingerling survival in rearing ponds, 1986 - 88.

nauplii), Daphnia and Chaoborus. Data from 1986 to 1988 were used to determine the correlation. The regression line in Fig 3 illustrates the relationship between usable zooplankton and fingerling survival. Two points (M1 87, and G 87) are excluded from the regression. Poor water quality (in Glaslyn Pond 1987) and pike predation (in Meadow 1 1987) resulted in low fingerling survival despite high crustacean standing crop. This regression line is the basis of the suitability index (SI) curve used to calculate V_2 in the HSI model described in sections 2.7.2 and 2.8.1. Good fingerling survival appears to occur at usable zooplankton concentrations greater than 130 zooplankters/L.

Appendices 12 to 14 present the results of stomach content analyses of walleye fingerlings from Codette, Jackfish, Meadow 1, Meadow 2, Glaslyn and Shore ponds. The data are expressed as percent frequency of occurrence. The data typify the usual changes of walleye prey items over time. Initially crustaceans (copepods and cladocerans) were selected. As growth continued, there was a shift to larger prey such as insect larvae. These were mainly dipterans such as chironomids and culicids (mainly Chaoborus). Other insects were also selected, including nymphs of damselflies, mayflies and dragonflies, and corixids. By the time the fingerlings reached harvest size (60-80 cm) they were selecting fish as prey if available. This was documented in Jackfish and Shore Ponds. In Jackfish Pond, spottail shiners (Notropis hudsonius) were being selected, although some evidence of cohort cannibalism was observed. In Shore Pond, spottail shiners were also found in the stomach

contents. The shiners were likely introduced during harvest procedures in both instances.

3.3 FINGERLING GROWTH

Increases in total length and weight of fingerlings sampled in the rearing ponds during 1988 are presented in Fig.4 and 5 (and listed in Appendix 15). Both curves were fit by eye. Data points were based on sample sizes ranging from 3 to 75 fingerlings (mean = 55).

Growth in length over an eighty day period was curvilinear. Increases in length fell within the ranges detailed by Liaw (1987), with the exception of fingerlings grown in Shore Pond. Growth in weight over the same 80 day period was sigmoidal, with the point of inflection at about 50 days after stocking. After this point, growth likely declined due to lack of food. Increases in weight also fell within the ranges detailed by Liaw (1987), again with the exception of Shore Pond.

3.4 SURVIVAL AND PRODUCTION

Fingerling production is summarized in Table 6. Survival of fry to fingerling size ranged from <0.1% in Shore Pond to 42.7% in Codette Pond. Population density at the time of harvest ranged from 4 (0.01 kg/ha) in Shore Pond to 28 194 fingerlings/ha (70.00 kg/ha) in Meadow 2. However, most of the fingerlings in Meadow 2 were unsuccessfully harvested due to

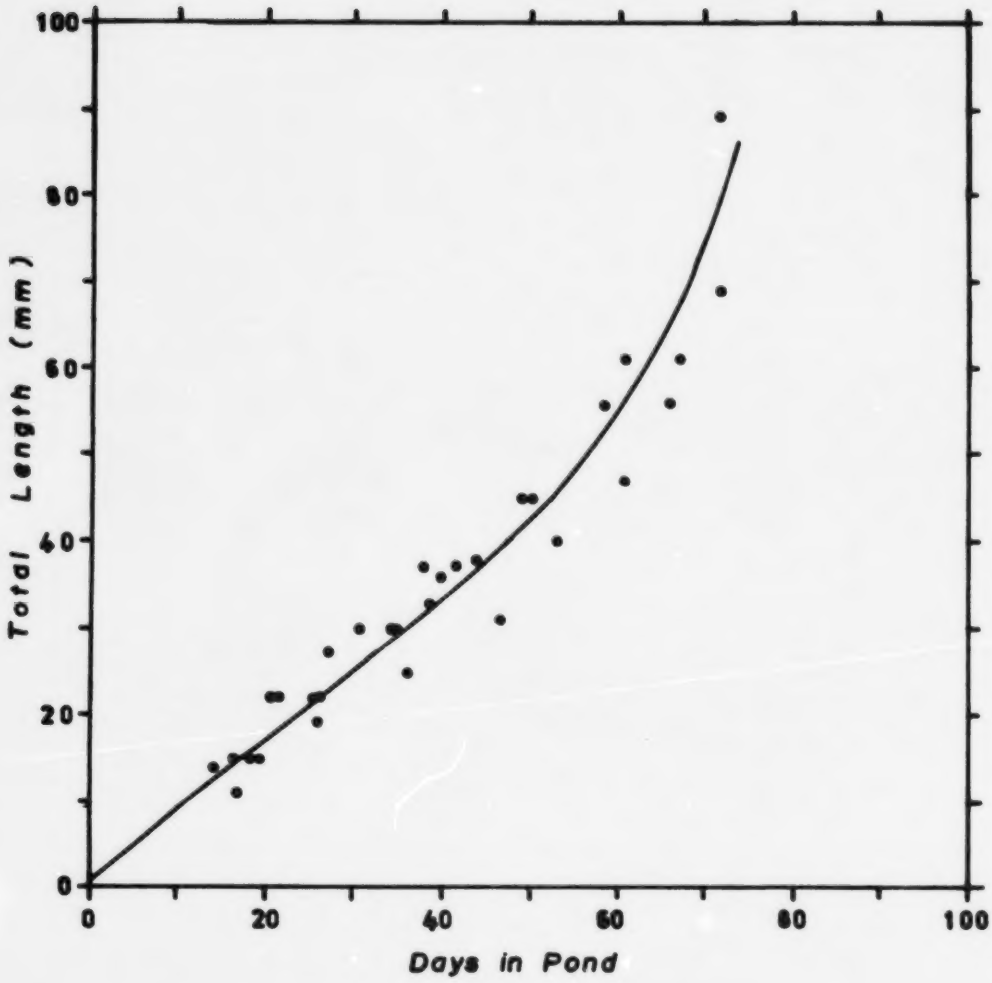


Figure 4. Increases in total length of walleye fingerlings, 1988. The curve fitted by eye illustrates the general growth trend. Sample sizes ranged from 3 to 75 (mean = 55)

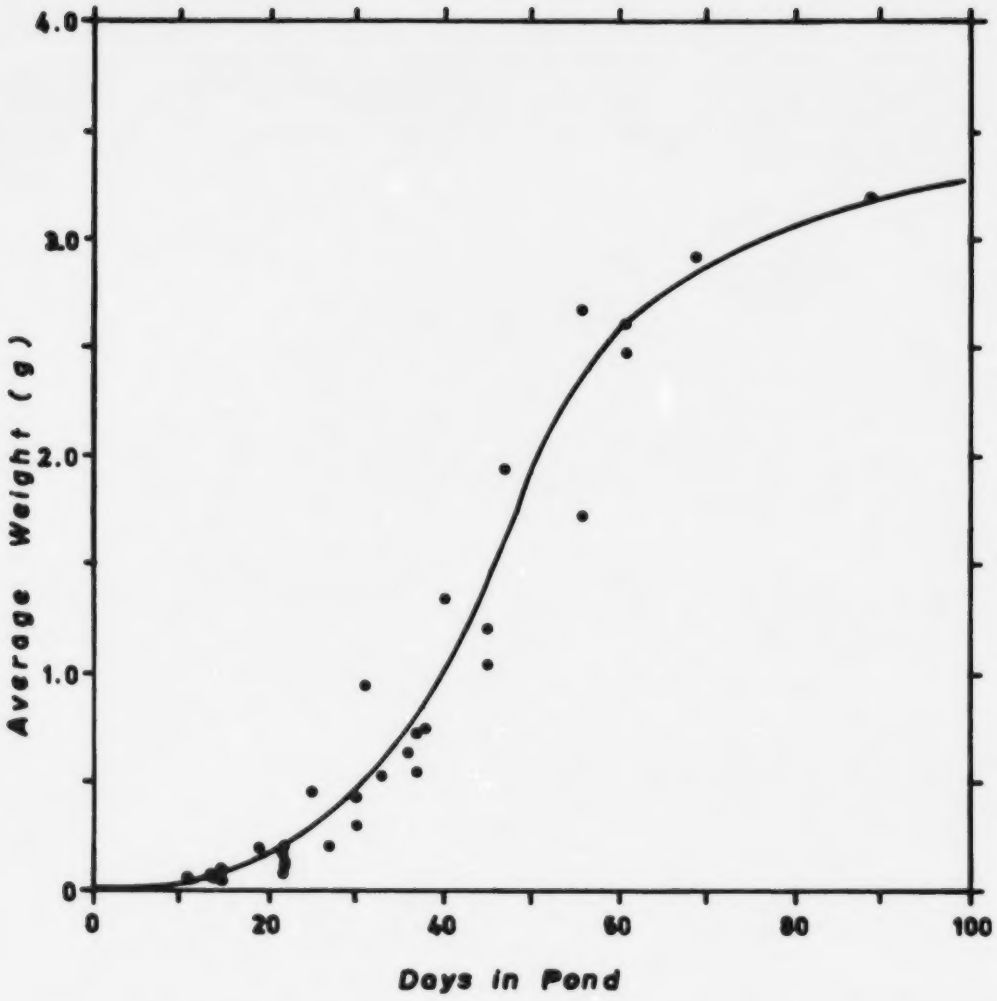


Figure 5. Increases in weight (g) of walleye fingerlings, 1988. The curve fitted by eye illustrates the general growth trend. Sample sizes ranged from 3 to 74 (mean = 55).

Table 6. Percent survival and estimated population density and yield of walleye fingerlings, 1988.

Pond	Estimated No. Fry Stocked	Days in Pond	Fingerling Population Estimate	% Surv.	Popn. Density (no./ha)	Yield** (kg/ha)
Codette	500 000	70	213 500 (± 15 384)	42.7	21 350	62.15
Jackfish	325 000	50	29 500 (± 2 253)	9.1	2 269	5.89
Meadow 1	310 000	63	94 800 (± 4 277)	30.6	15 290	26.18
Meadow 2	270 000	61	101 500*	37.6*	28 194*	70.00*
Glaslyn	100 000	56	2 100	2.1	525	1.40
Shore	120 000	89	76	>0.1	4	0.01
TOTAL	1 625 000		441 476	27.2	7 912	

* Poor water quality and inability to rapidly draw down (and completely drain) Meadow 2 resulted in a recovery of only 21 500 of the 101 500 fingerlings produced.

** Based on average weight of fingerlings at harvest.

NB/ Number in brackets is the 95% Confidence Limit of the population estimate.

logistical problems during pond drainage and poor water quality.

A mean survival rate of 31.3% was achieved in rearing fry to harvest size in the fertilized ponds (Codette, Jackfish, Meadow 1 and 2), and only 1% in the unfertilized ponds (Glaslyn and Shore). An overall survival rate of 27.2% was achieved in all ponds this year. This reflects an overall production of 7 912 fingerlings/ha in the six rearing ponds.

An estimated 441 476 fingerlings were produced in the six rearing ponds during the 1988 season. These were stocked in Codette Resevoir (200 000), Smuts Lake (4 800), Martin's Lake (10 500), Turtle Lake (90 000), Attons Lake (7 000), Greig Lake (9 500), Meadow River (7 000), Jackfish Lake (24 300) and Murray Lake (5 200). The remainder were lost to harvest mortality.

3.5 POND HABITAT SUITABILITY INDEX (HSI)

The HSI model outlined in sections 2.7 and 2.8 was used to calculate the life requisite components and habitat suitability ratings of the rearing ponds in 1988. The life requisite values and HSI ratings are presented in Table 7. The suitability index (SI) values used for calculating the values in Table 7 are presented in Appendix 16. The fertilized ponds (Codette, Meadow 1, Meadow 2 and Jackfish) had higher HSI ratings than the unfertilized ponds (Glaslyn and Shore). Codette and Meadow 2 had very similar HSI values and coincidentally had the highest fingerling survival rates (Table 6). Meadow 1 also received a favorable HSI rating. Shore Pond had the lowest HSI

Table 7. Life Requisite and HSI determinations for the rearing ponds, 1988. (Values are determined from the suitability index (SI) scores in Appendix 16.)

	Life Requisite Components				
Pond	Food (C_F)	Cover (C_C)	Water Quality (C_{WQ})	Trophic Status (C_{TS})	HSI Rating
Meadow 2	0.83	0.82	0.89	1.00	0.82
Codette	0.81	0.97	0.90	1.00	0.81
Meadow 1	0.90	0.96	0.76	1.00	0.76
Jackfish	0.66	0.81	0.76	1.00	0.66
Glaslyn	0.49	0.83	0.42	0.75	0.42
Shore	0.40	0.85	0.00	0.45	0.00

rating being limited mainly by water quality, food and trophic status. Glaslyn Pond was limited by water quality and food.

4. DISCUSSION

Habitat Evaluation Procedures (HEP) were first developed by the U. S. Fish and Wildlife Service (USFWS) as a standardized species-habitat approach for conducting impact assessments. Habitat quality for a selected evaluation species (walleye in this case) is documented with a Habitat Suitability Index (HSI). This value is derived from an evaluation of the ability of key habitat components to supply the life requisites of the selected evaluation species. Evaluation involves using the same key habitat components to compare existing habitat conditions and optimum habitat conditions for the species of interest. Optimum conditions are those associated with the highest potential densities of the species within a defined area. The HSI value obtained from this comparison thus becomes an index to carrying capacity for that species (USFWS 1980).

The HSI index ranges from 0.0 (unsuitable) to 1.0 (optimum), and for operational purposes in HEP, each increment of change must be identical to any other. Therefore, HSI must be linearly related to carrying capacity (USFWS 1980).

A comparison of HSI ratings (Table 7) between the rearing ponds and their fingerling production (Table 6) reveals the expected trends predicted by the rearing pond model output. A significant correlation ($r=0.95$, $p<0.05$) exists between the HSI

ratings and pond yield (kg/ha) for the fertilized ponds (Fig. 6). Although a trend is apparent, more data are required to make the relationship more statistically valid. Meadow 2 Pond had the highest HSI rating (0.82); and correspondingly had the highest production (70.0 kg/ha; 28 194 fingerlings/ha). According to the model, fingerling survival was limited by the food (C_F) and cover (C_C) components of the model, specifically by the mean Secchi disc depth (V_1 in Appendix 16). Throughout most of the summer, high levels of blue-green algae reduced light penetration in the pond. The low SI rating for Secchi disc (V_1) resulted in low food (C_F) and cover (C_C) life requisite values, which in turn was reflected in the Meadow 2 HSI rating. As stated in the model, feeding efficiency is reduced in very turbid waters (McMahon et al. 1984).

Codette Pond had a slightly lower HSI rating (0.81)as well as a slightly lower production (62.15 kg/ha; 21 350 fingerlings/ha) compared to Meadow 2 Pond. This follows the model prediction. A low V_F (mean zooplankton concentration) resulted in a low food life requisite (compared to the other life requisites for the pond). This was reflected in the HSI rating for Codette.

Meadow 1 Pond received an HSI rating of 0.76. Water quality was the factor limiting production in this pond according to the model. A depressed oxygen level above the thermocline (V_5) during the hot weather in early June was reflected in the water quality life requisite, which in turn lowered the pond's HSI rating.

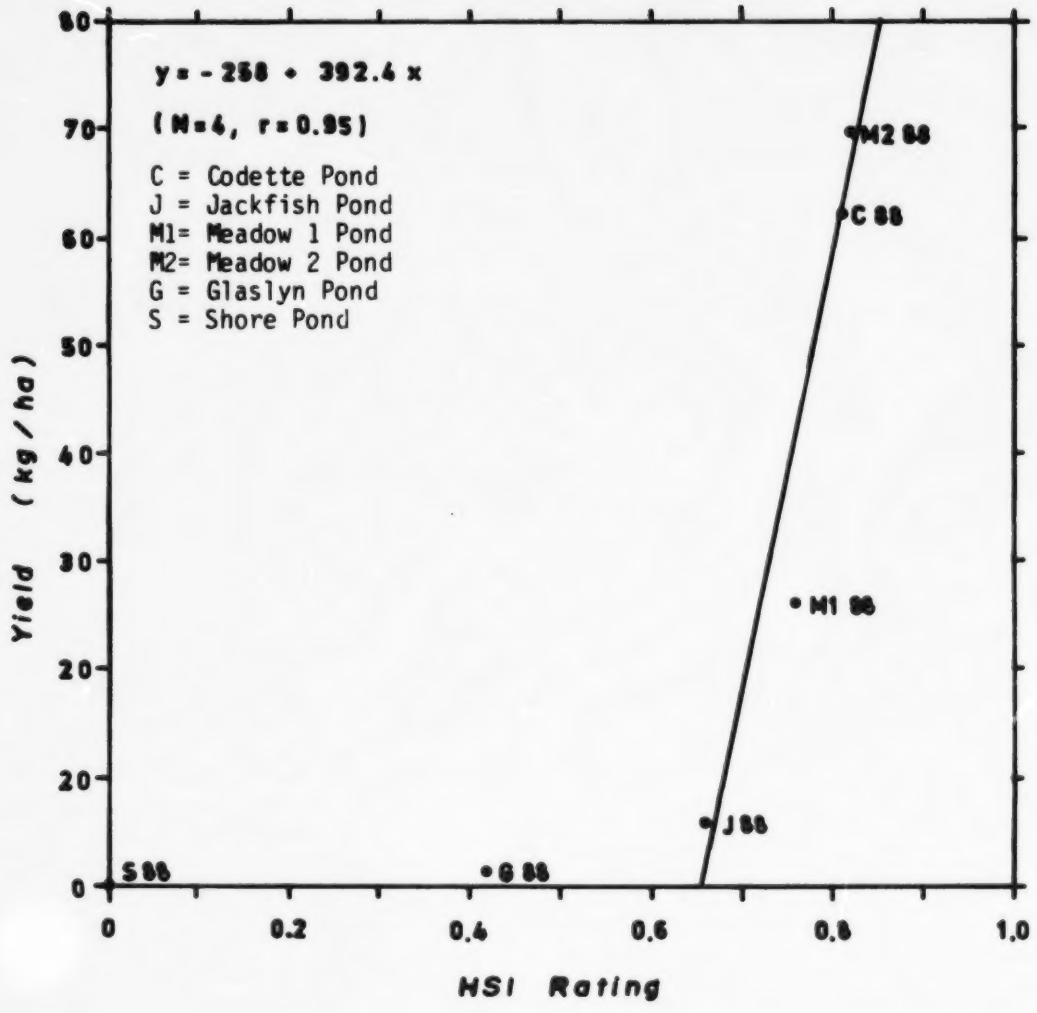


Figure 6. Correlation between fingerling yield (kg/ha) and HSI for the fertilized rearing ponds. The un-fertilized ponds were excluded from the regression.

Jackfish Pond production was limited by food, specifically by V_2 (mean zooplankton concentration). The low zooplankton concentration at the time of stocking may have inhibited the fingerlings from developing a prey image which in turn prevented feeding initiation. Thick growth of submersed macrophytes may interfere with feeding and movement of fish resulting in starvation (Liaw 1987).

Glaslyn and Shore Ponds received the lowest HSI ratings. Fingerling survival in both ponds was limited by water quality (specifically by V_7 - mean weekly un-ionized ammonia level) and food availability (V_2 - mean weekly zooplankton concentration). These problems were most pronounced in Shore Pond.

The limiting factors identified by the model could be confirmed in field data, giving validity to the analytical procedure. Food and water quality were the main factors identified. In the case of low food levels, mitigation could be in the form of additional fertilization. Where low DO levels become the limiting factor, as it was in Meadow 1 Pond, aeration could solve the problem. The un-ionized ammonia concentration is dictated by pH, temperature, and the utilization and production by various bacterial populations (Hampson 1976). Therefore, control of un-ionized ammonia levels is very difficult in the natural rearing pond environment.

A comparison of production between the fertilized (Codette, Meadow 1, Meadow 2 and Jackfish) and unfertilized ponds (Glaslyn and Shore) shows that fingerling production is

higher in the fertilized ponds where the usable zooplankton concentration is higher. This is best illustrated in Fig. 3 where a highly significant correlation ($r=0.872$, $p<0.01$) was found between fingerling survival (%) and the usable zooplankton concentration (no./L). Two points (M1 87, G 87) were omitted from the regression because low fingerling survival despite a high zooplankton concentration was attributed to other causes. Li and Mathias (1982) and Liaw (1987) suggested that usable zooplankton densities between 100 to 200 organisms/L are required to foster good fingerling production. From this regression, which is based on three field seasons, it appears that good fingerling survival appears to occur at mean usable zooplankton concentrations greater than 130 zooplankters/L. In order to achieve these levels of zooplankton production, the rearing ponds must be fertilized.

Pond fertilization is limited by cost and the time required to handle large quantities of fertilizer, and by the effects on the pond water quality. Water quality data from the Meadow Lake Ponds (Appendices 6-8) indicate that the present pond fertilization practice had limited impact on the overall water quality of the Meadow River.

Usable zooplankton in this regression is defined as the total number/L of Daphnia, copepods, and Chaoborus. These organisms were selected because previous studies indicate they are the preferred forage species. Crustaceans such as rotifers, copepod nauplii, Bosmina, and Ceriodaphnia, are not utilized as forage because of their small size (Arsenault 1987a and b, Liaw

1987). Fish always select the largest food item they can ingest and as they grow, the optimum size of the food item also increases. This size selection is due in part to an increase in distance between the gill rakers (as walleye fingerlings grow) which allow smaller, less energy efficient, particles to pass through (Rutledge 1984, Begon and Mortimer 1981). This relationship, between the mean usable zooplankton concentration and percent fingerling survival, can be used as a crude predictive method for estimating pond production.

Production of fingerlings to harvest size increased from 10 200 fingerlings/ha in 1987 to 13 400 fingerlings/ha in 1988, in the fertilized ponds (Codette, Meadow 1, Meadow 2, Jackfish). This increase may be partially accredited to an increase in stocking and fertilization rates.

Another empirical relationship between the mean weekly un-ionized ammonia concentration and fingerling survival (Fig. 2) was found to be highly significant. The same two points (M1 87, G 87) were excluded from the regression. The low fingerling survival in those two ponds was attributed to pike predation in Meadow 1 Pond (1987) and low DO levels in Glaslyn Pond (1987). The regression should be interpreted with care as a Hach kit was used in the determinations of ammonia-nitrogen. These test kits are used under the relatively uncontrolled conditions that exist at field sites, and are designed to rapidly determine ammonia levels in a wide range of water sample types. Therefore the quality of the analyses may be compromised by the crudity of the methods. Rosenthal and Gershey (1986) concluded that the

reliability of nitrogen species determinations depends largely on the organic load in the water sample (as a result of interference with color development). The test kits themselves possess warnings of interference of the colorimetric reaction caused by the formation of solid particles of magnesium hydroxide biproduct (in testwater containing more than 6 grains/gallon (616 mg/L) hardness), and by the Nessler Reagent itself (in water samples containing low ammonia-nitrogen levels). These interferences were found to occur in the ponds.

5. CONCLUSIONS

A strong correlation between the usable zooplankton density and fingerling survival exists, suggesting the importance of high zooplankton abundance for pond culture success. Food was a limiting factor in some of the ponds indicating that increased fertilization rates in the rearing ponds is required. Water quality problems were also limiting to fingerling production. In some cases the effects may be mitigated through aeration, or pond acidification.

A walleye HSI model was modified to evaluate Saskatchewan rearing ponds. The model was tested using field data from six rearing ponds operated during 1988. A significant correlation exists between fingerling production (yield) and the HSI scores of the fertilized ponds. More field testing will be required for a more statistically valid comparison between pond production and the model outputs. The model helped identify

factors that are limiting to fingerling production in each of the ponds for the 1988 growing season. With more field testing, it should be possible to refine the model to a level of high precision for use in Saskatchewan rearing pond evaluations.

6. RECOMMENDATIONS

Table 8 summarizes the recommendations for the 1989 rearing pond operations for Codette, Jackfish, Meadow 1, Meadow 2, Glaslyn and Shore ponds.

6.1 POND FERTILIZATION

The use of alfalfa hay bales and alfalfa pellets should continue. However, the use of superphosphate should be terminated as it creates problems of heavy macrophyte and filamentous algae growth.

Codette and Meadow Lake Ponds should receive alfalfa bales at a rate of 15 bales/ha. Alfalfa pellets should be applied at a rate of 400 kg/ha 10-14 days before stocking and again at 3 days before stocking. The remaining bags of pellets should be applied in equal amounts of 2-3 applications beginning 1 week after stocking.

Jackfish and Shore Ponds should receive alfalfa pellets in 4 equal weekly applications beginning 10 days before stocking. Glaslyn should be operated as a natural pond with no fertilization.

Table 8. Rearing pond operation recommendations, 1989.

Pond	Area (ha)	Stocking Rate (fry/ha)	Total	Alfalfa (kg/ha)	Pellets (no. bags)	Alfalfa Hay Bales
Codette	10.0	50 000	500 000	1 400	560	150
Jackfish	13.0	30 000	390 000	1 200	625	-
Meadow 1	6.2	75 000	465 000	1 400	347	95
Meadow 2	3.6	75 000	270 000	1 400	201	55
Glaslyn	4.0	25 000	100 000	-	-	-
Shore	19.0	20 000	380 000	1 000	760	-
Total			2 125 000		2 492	300

6.2 FRY STOCKING

Proposed stocking rates for 1989 are presented in Table 8. An increase of 25 000 fry/ha for Meadow 1 Pond, and 15 000 fry/ha for Shore Pond are recommended. On the basis of plankton standing crop, Glaslyn and Shore ponds should probably be stocked earlier than they were in 1988. Enumeration of fry by volumetric measurement of eyed eggs (von Bayer method) should again be conducted to provide an accurate count of numbers being stocked and allow accurate evaluations at harvest.

6.3 MONITORING PROCEDURES

Water temperature, DO, pH, ammonia-nitrogen, chlorophyll a, zooplankton concentration, water transparency (Secchi disc) and pond water level should be monitored prior to pond fertilization and weekly throughout the culture period. The zooplankton concentration should be monitored weekly from the time of filling the pond with water until the end of June to assess the forage availability and effectiveness of pond fertilization.

Weekly sampling of walleye by seine or trap should begin 2 weeks after stocking. A minimum of 50 fingerlings/ sample should be collected to monitor fingerling growth rate and determine the diet composition.

The percent cover and organic content of pond sediment should be measured in late June.

6.4 HARVEST METHODOLOGY

Mark/recapture is the preferred procedure for population estimation to minimize fingerling stress. It is recommended that this be done at all ponds prior to harvest.

The inability to hold large numbers of fingerlings destined for other lakes was a problem. This may be remedied by use of a portable swimming pool containing a clean water supply. Bottled oxygen should be kept on standby for emergency aeration. In addition, construction of a portable harvest net with a large holding area is required for efficient harvesting of fingerlings at all ponds.

The use of anesthetics should be considered, to reduce fish metabolism during holding. MS 222 is effective but common salt (NaCl) has been effectively used by Ontario culturalists and fish farmers. If salt is used, a 1% solution (with clean water) should be prepared before fish are added to the water.

Fingerling harvesting is recommended at 50 - 60 days post stocking (mid-July). At this time, food is usually becoming limited in the ponds.

Agitation and bottled oxygen has been used when transporting fingerlings. However agitation was found to be stressful on the fingerlings, especially if water quality is poor. It is recommended that only oxygen should be used (and checked frequently while in transit) in conjunction with clean water. This was found to be a superior method in hauling fingerlings from the Meadow Pond complex.

6.5 POND ALTERATION AND DESIGN

Emergent growth in Jackfish Pond was a problem in 1988. Mechanical removal or disking of plant material, and deepening of the pond basin over a 4.0 ha area around the deepest part of the pond (near the drainage gate) is recommended to facilitate more effective aeration and reduction of macrophyte cover to a more optimum level (20% instead of the 60% cover presently existing).

Additional sloping of the Meadow 2 Pond basin is recommended to speed pond drawdown and allow more of the pond to be completely drained. This will prevent stranding of fingerlings and reduce the time interval where the fingerlings are vulnerable to intense bird predation. Use of a scare cannon may also aid in reducing the bird predation problem at the Meadow Ponds.

Construction of a small catch pond for Glaslyn Pond, using riprapping, will allow more efficient harvest of fingerlings by trapping.

Codette Pond will need some basin leveling in 1989. There are some low spots that hold enough water to promote excessive macrophyte growth. Channelization of the pond outflow is recommended to prevent trapping fingerlings in between the riprapping when water flow is shut off.

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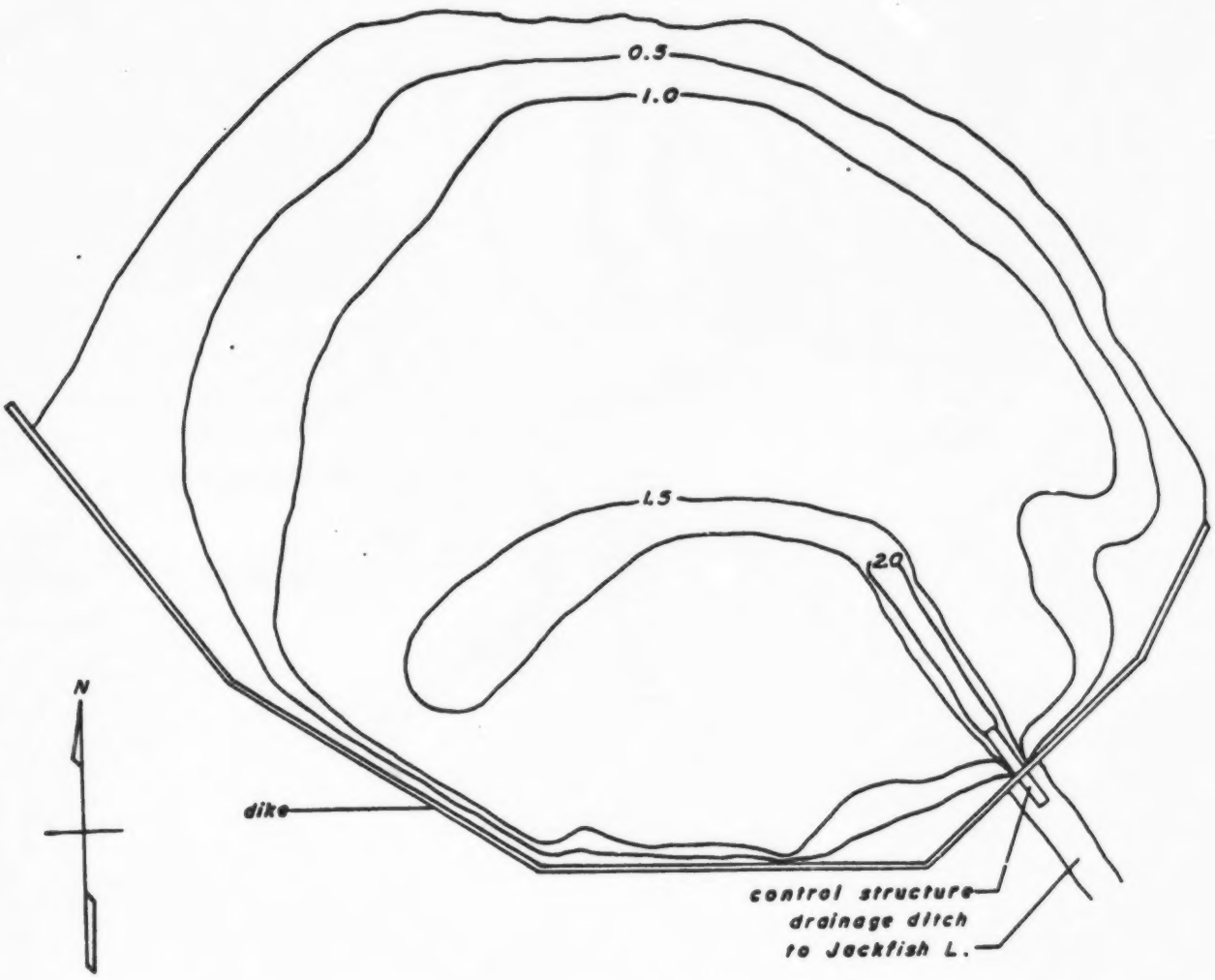
8. APPENDICES

CODETTE POND 1987
metres
0
50
100
20-49-17-W2
Depth in metres
0.5
1.0
1.5
2.0
2.1
2.2
2.2
0.5
1.0
CODETTE RESERVOIR
N
INLET
SPC pump station
spillway
pump ramp
control structure
dike

Appendix 1

N
MEADOW RIVER
CELL 2
CELL 1
1.0
2.0
2.5
2.5
2.5
2.0
1.0
dike
spillways
control structures
pump ramp
catch pond 1
control weirs
catch pond 2
MEADOW LAKE POND 1987
metres
0
50
100
25-59-17-W3
Depth in metres

Appendix 2



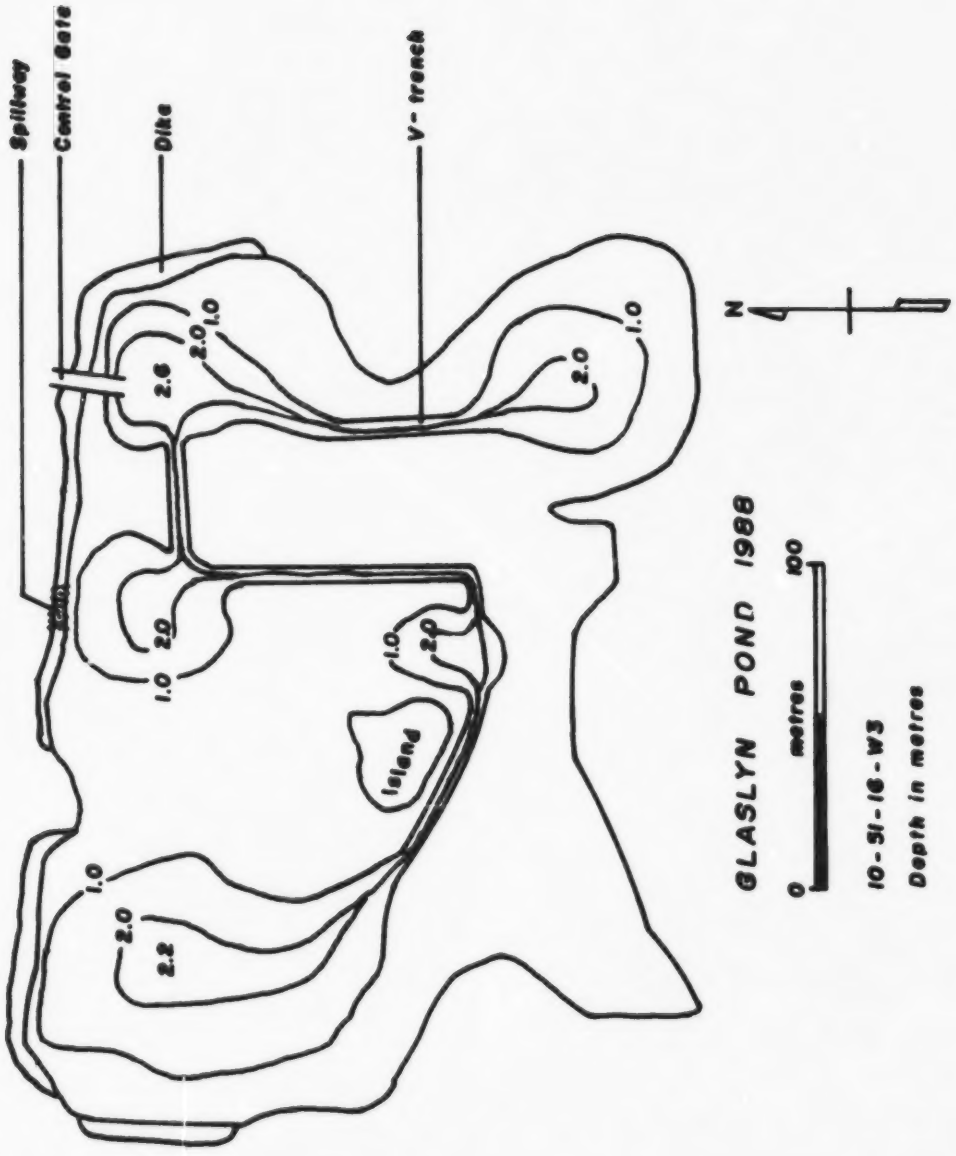
JACKFISH POND 1987

metres
0 50 100

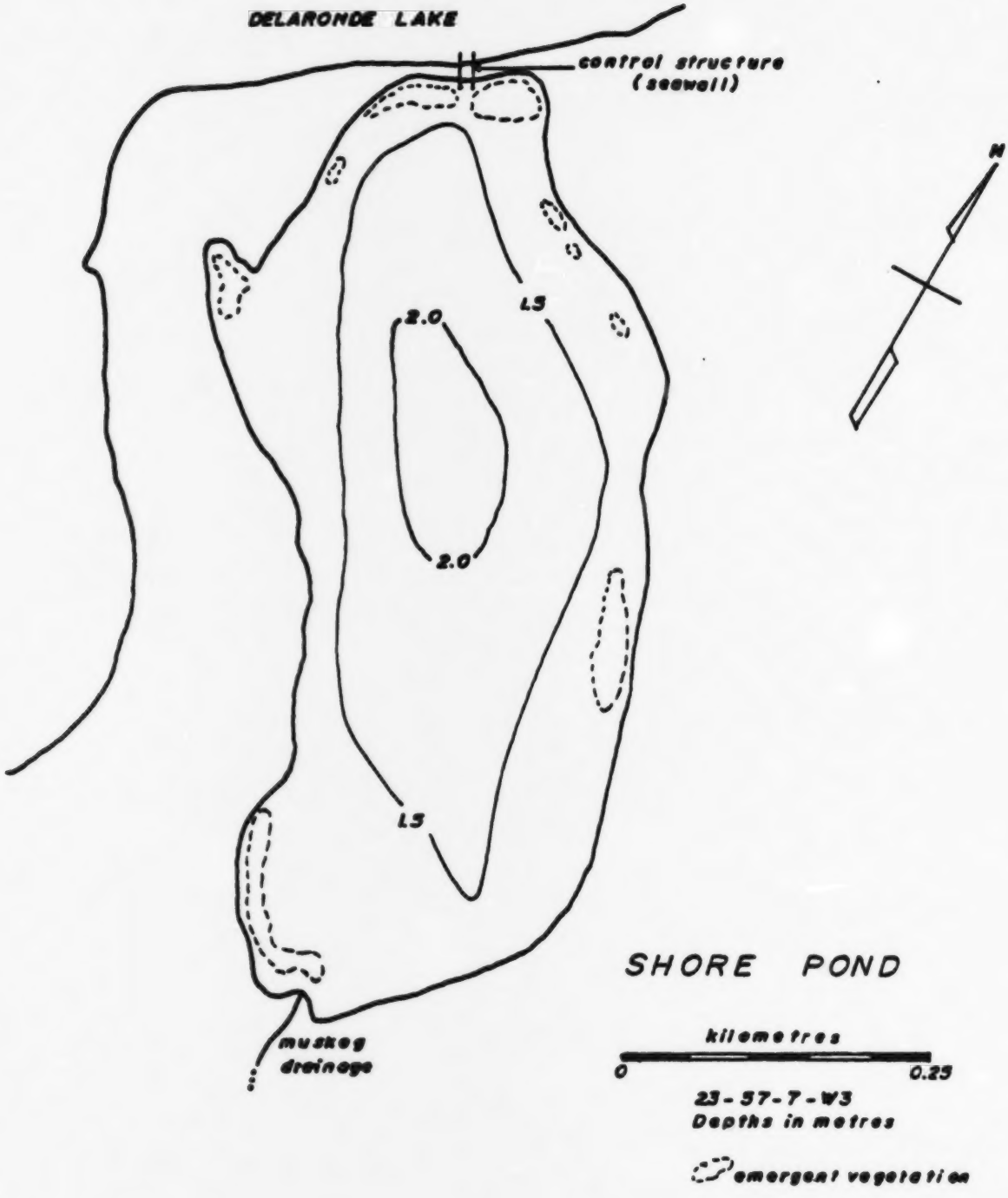
9-48-17-W3

Depth in metres

Appendix 3


Spillway
Control Gate
Dike
V- trench
2.6
2.0
1.0
2.0
1.0
2.0
1.0
2.0
1.0
2.0
2.2
Island
N
GLASLYN POND 1988
0
metres
100
10-31-18-W3
Depth in metres

Appendix 4


DELARONDE LAKE
control structure
(seawall)
N
2.0
LS
2.0
LS
muskeg
drainage
SHORE POND
kilometres
0
0.25
23-57-7-W3
Depths in metres
emergent vegetation

Appendix 5

Appendix 6. Water analyses results - Meadow Lake Rearing Ponds, 1988. Units in mg/L unless otherwise indicated.

Location	Meadow 1		Meadow 2	
Date Sampled	22July88	28July88	22July88	28July88
Parameter				
pH	9.20	9.00	8.30	8.70
Calcium	24.00	32.00	70.00	61.00
Iron	0.20	0.30	0.20	0.30
Magnesium	39.00	40.00	27.00	31.00
Manganese	0.03	0.05	<0.01	0.04
Potassium	-	8.00	-	-
Sodium	36.00	38.00	34.00	41.00
Bicarbonate	166.00	186.00	261.00	264.00
Carbonate	27.00	35.00	-	12.00
Chloride	28.00	26.00	14.00	28.00
Sulphate	89.00	87.00	112.00	100.00
Phosphate - total	0.26	0.26	0.23	0.35
- ortho	0.08	<0.25	0.02	<0.25
Nitrogen - Kjeldahl	5.50	3.70	4.80	5.00
- ammonia	1.27	2.25	0.66	3.50
- nitrate	<0.03	<0.03	<0.03	<0.03
DOC	34.00	30.00	37.00	35.00
Total alkalinity as CaCO3	181.00	211.00	214.00	237.00
Phenol alkalinity as CaCO3	-	29.00	-	10.00
Total hardness as CaCO3	220.00	244.00	288.00	280.00
Suspended solids - total	24.00	17.00	26.00	17.00
- volatile	12.00	6.00	11.00	8.00
Conductivity (uS/cm)	545.00	-	632.00	-
Total dissolved solids	409.00	417.00	519.00	537.00
BOD (5 days)	4.50	3.00	5.00	3.60

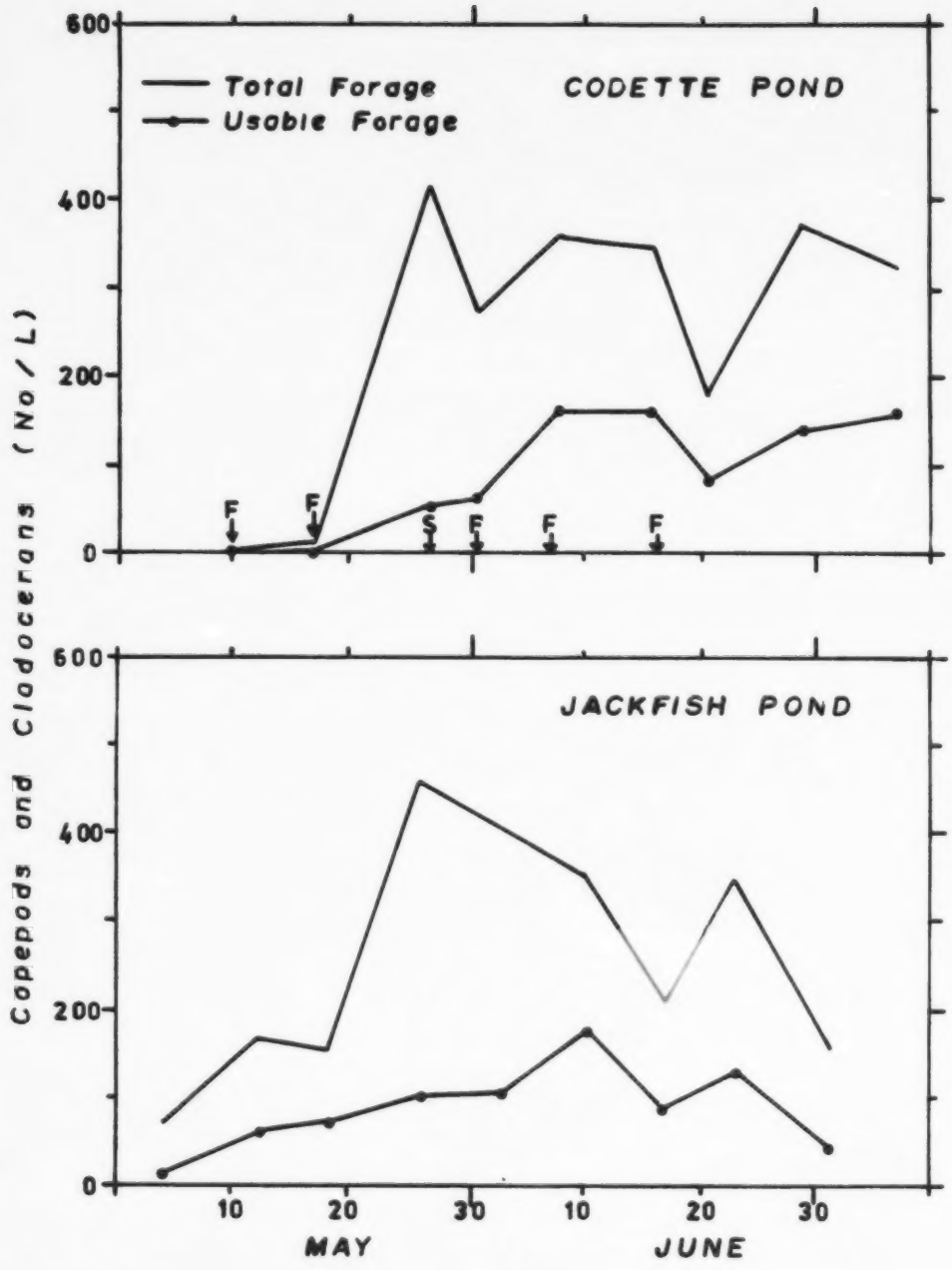
Appendix 7. Water analyses results - Meadow Lake drainage canal, 1988. Units in mg/L unless otherwise indicated.

Location	Drainage Canal leading from the rearing ponds to Meadow River	
Date Sampled	Site 1 22July88	Site 2 22July88
Parameter		
pH	8.80	8.60
Calcium	45.00	40.00
Iron	1.10	0.70
Magnesium	35.00	26.00
Manganese	<0.01	<0.01
Potassium	-	-
Sodium	30.00	19.00
Bicarbonate	198.00	222.00
Carbonate	-	8.00
Chloride	18.00	14.00
Sulphate	97.00	31.00
Phosphate - total	0.12	0.10
- ortho	0.02	<0.03
Nitrogen - Kjeldahl	2.10	2.10
- ammonia	0.12	0.15
- nitrate	<0.03	<0.03
DOC	23.00	21.00
Total alkalinity as CaCO3	181.00	195.00
Phenol alkalinity as CaCO3	-	-
Total hardness as CaCO3	256.00	208.00
Suspended solids - total	106.00	63.00
- volatile	19.00	10.00
Conductivity (uS/cm)	544.00	416.00
Total dissolved solids	434.00	360.00
BOD (5 days)	0.80	1.80

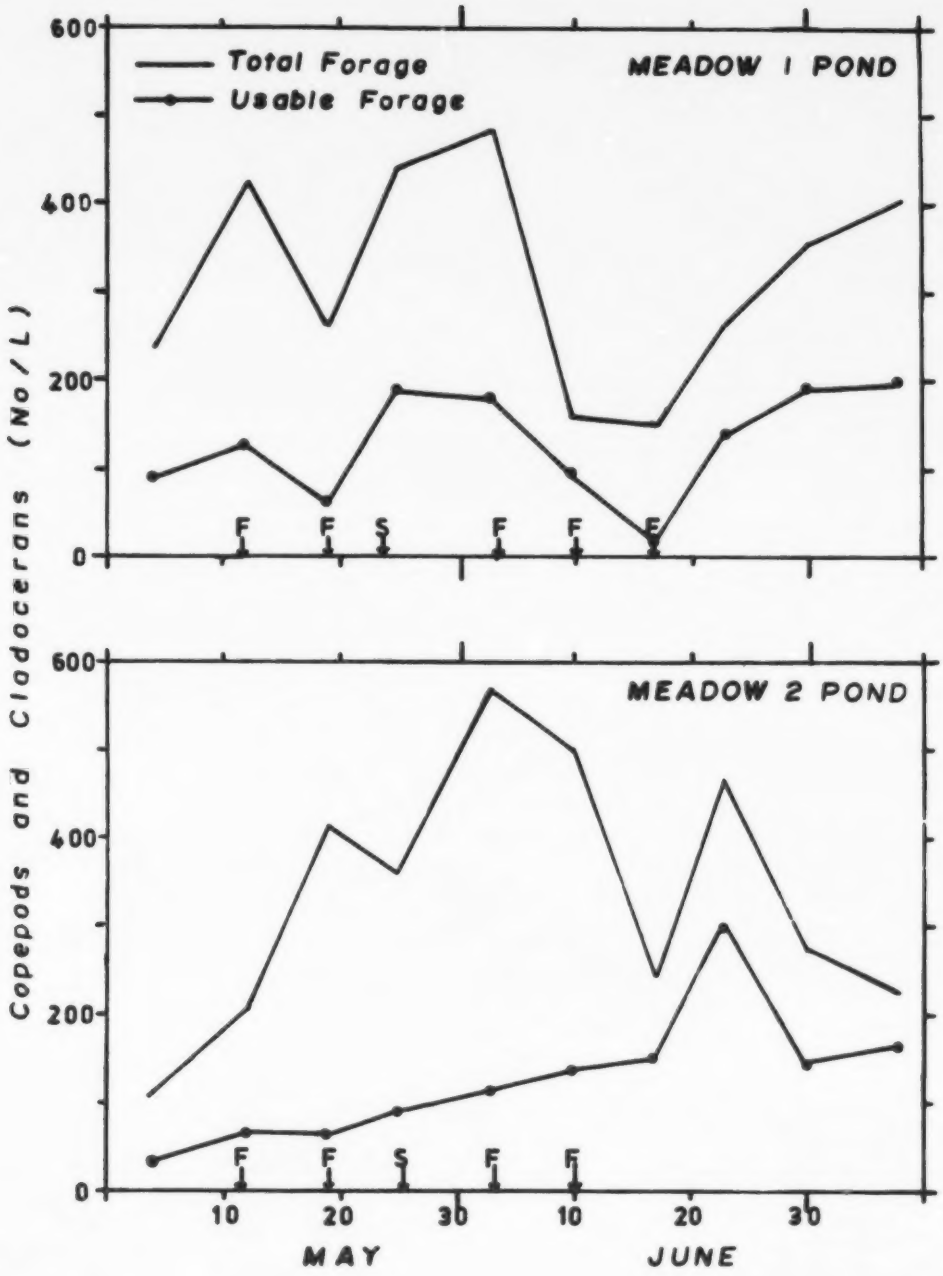
Appendix 8. Water analyses results - Meadow River, 1988. Units in mg/L unless otherwise indicated.

Location	Meadow River *		Meadow River **	
Date Sampled	22July88	28July88	22July88	28July88
Parameter				
pH	8.50	8.90	8.50	8.20
Calcium	50.00	30.00	50.00	34.00
Iron	2.50	0.80	2.40	0.70
Magnesium	16.00	39.00	22.00	30.00
Manganese	0.02	0.01	<0.01	<0.01
Potassium	-	8.00	-	6.00
Sodium	17.00	37.00	17.00	20.00
Bicarbonate	242.00	202.00	249.00	258.00
Carbonate	-	24.00	-	-
Chloride	8.00	26.00	8.00	14.00
Sulphate	18.00	88.00	17.00	31.00
Phosphate - total	0.25	0.46	0.23	0.23
- ortho	0.03	0.04	0.03	0.07
Nitrogen - Kjeldahl	2.80	6.10	2.40	2.90
- ammonia	0.13	1.21	0.15	0.62
- nitrate	0.03	<0.03	<0.03	<0.03
DOC	21.00	33.00	19.00	22.00
Total alkalinity as CaCO3	205.00	206.00	209.00	212.00
Phenol alkalinity as CaCO3	-	8.00	-	6.00
Total hardness as CaCO3	192.00	236.00	216.00	208.00
Suspended solids - total	23.00	92.00	136.00	66.00
- volatile	9.00	41.00	53.00	21.00
Conductivity (uS/cm)	393.00	-	410.00	-
Total dissolved solids	355.00	454.00	366.00	387.00
BOD (5 days)	3.00	9.00	2.50	2.40

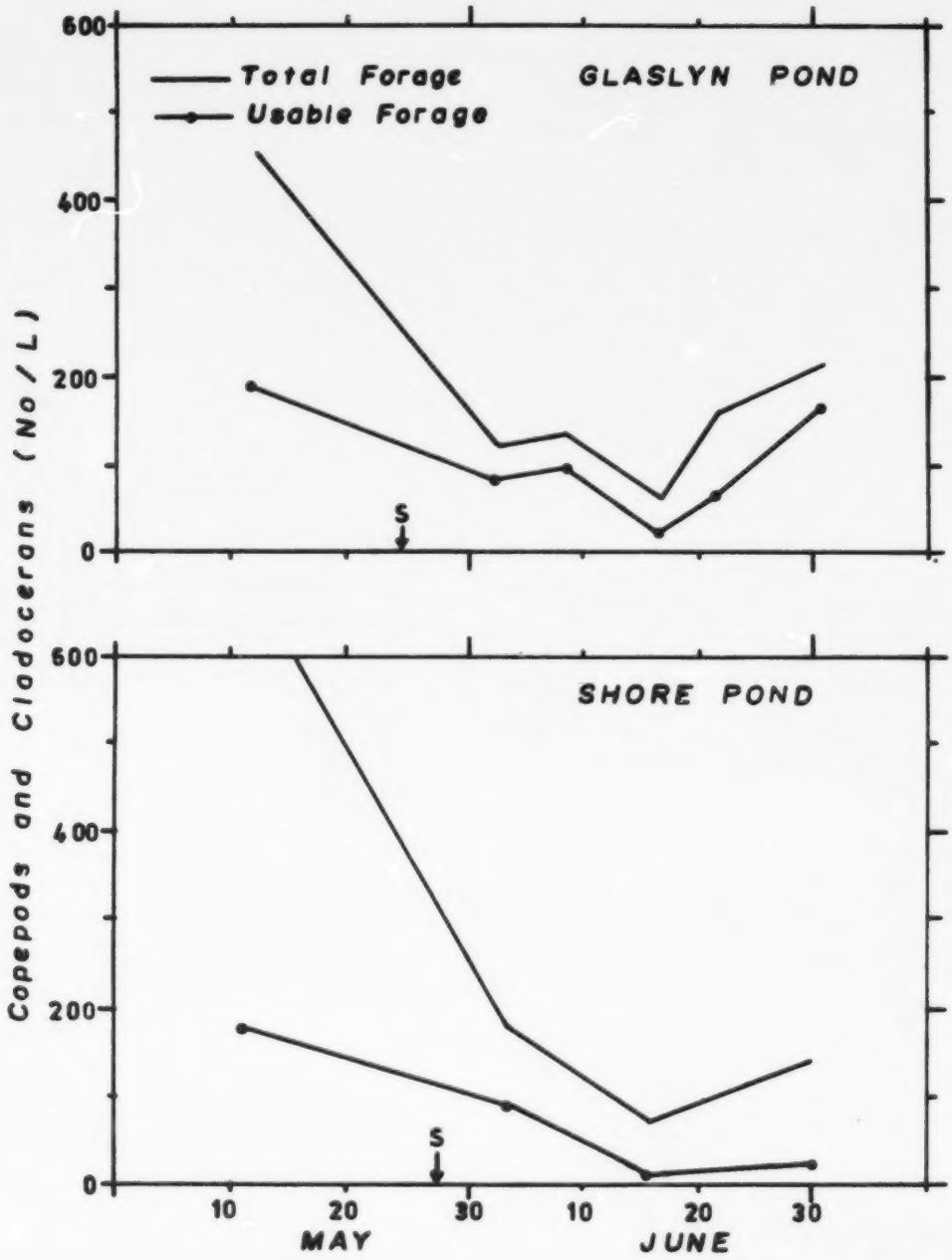
* upstream of drainage canal.
** at town water treatment plant intake.



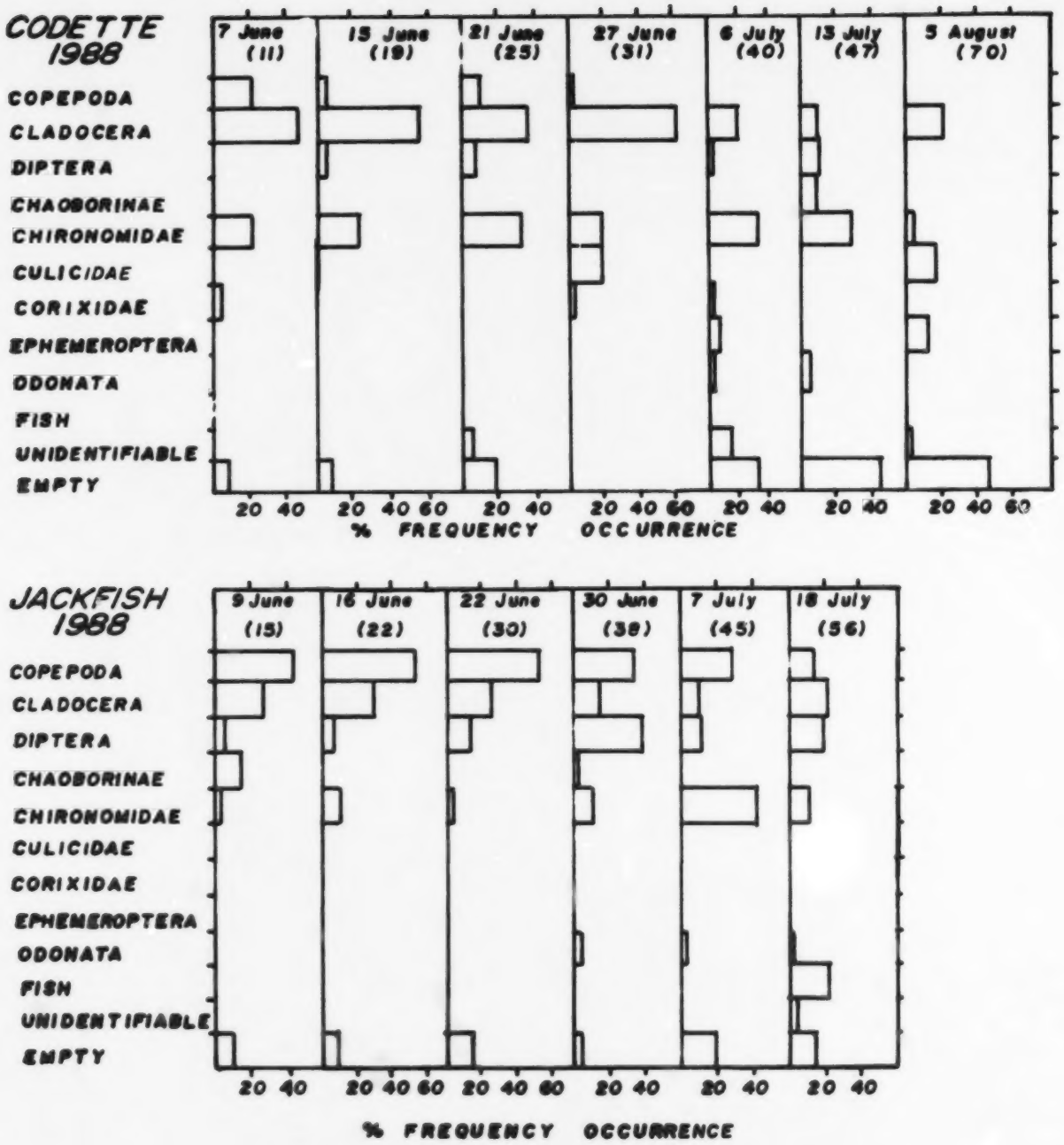
Appendix 9. Changes in zooplankton standing crop for Codette and Jackfish rearing ponds, 1988. The arrows indicate dates fertilized (F) or stocked (S).



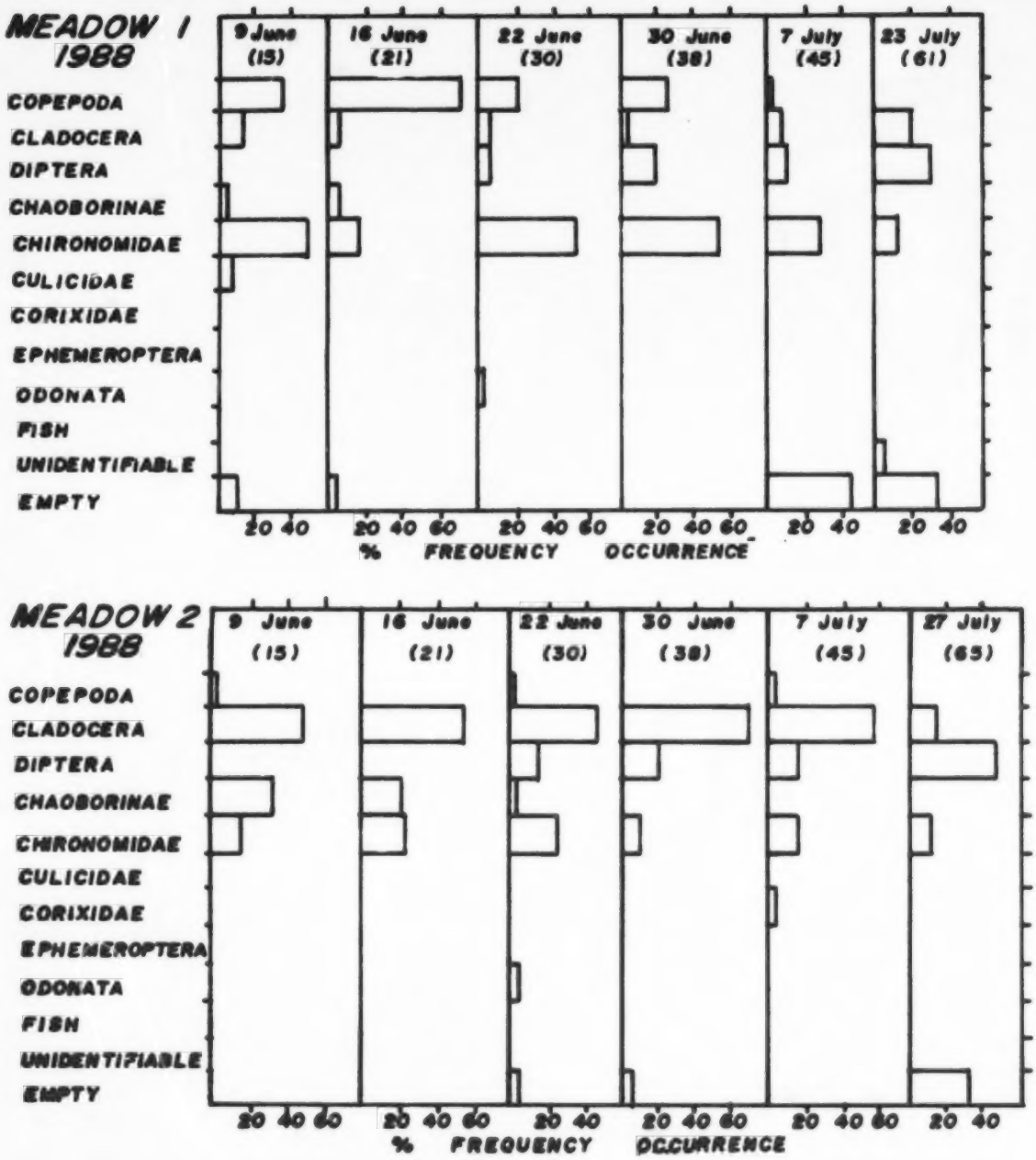
Appendix 10. Changes in zooplankton standing crop for Meadow 1 and Meadow 2 rearing ponds, 1988. The arrows indicate dates fertilized (F) and stocked (S).



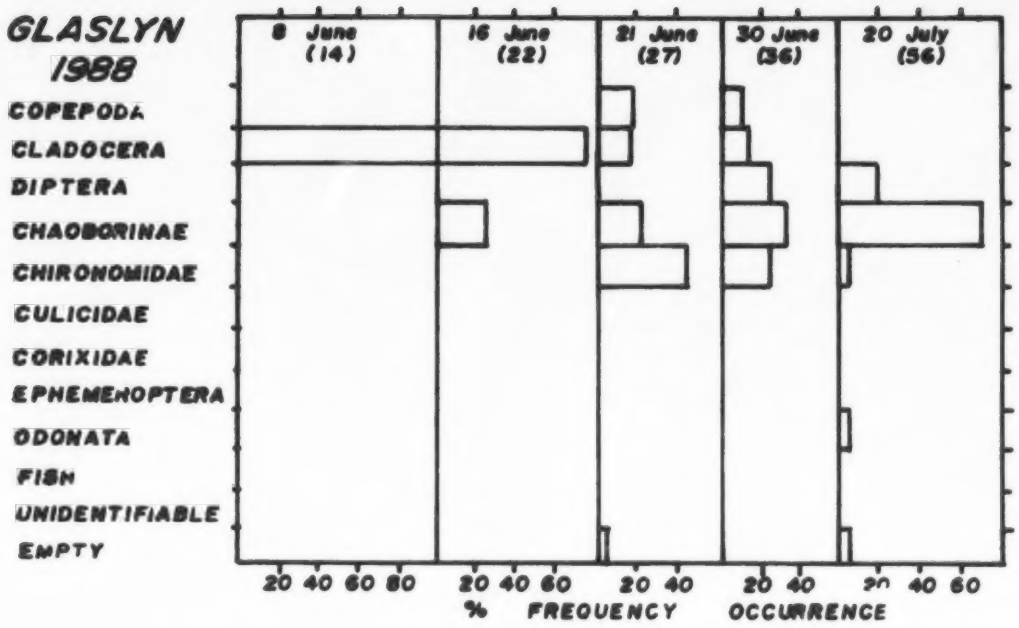
Appendix 11. Changes in zooplankton standing crop for Glaslyn and Shore rearing ponds, 1988. The arrows indicate the dates stocked (S).

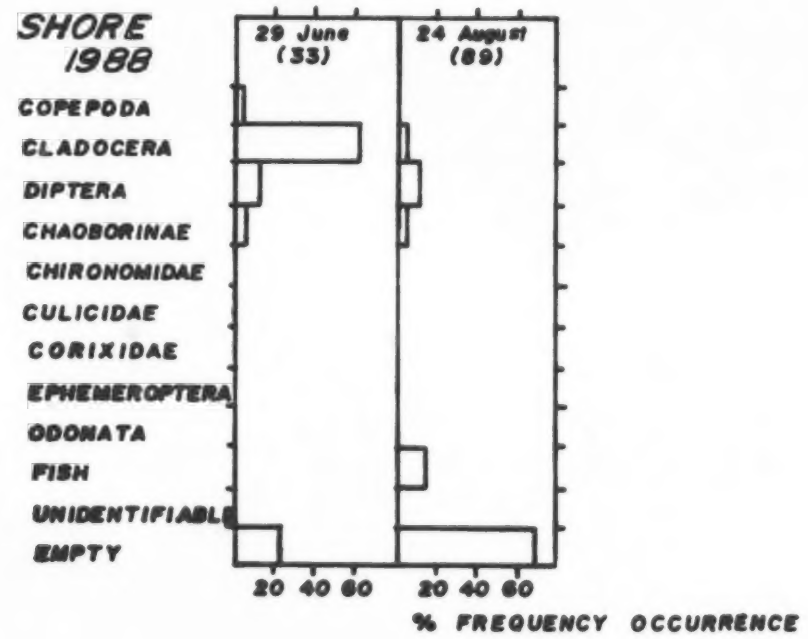


Appendix 12. Percent frequency of occurence of various food items in walleye stomach contents per sample period, from Codette and Jackfish Ponds, 1988. The number in brackets is days after stocking.



Appendix 13. Percent frequency of occurence of various food items in walleye stomach contents per sample period, from Meadow 1 and Meadow 2 Ponds, 1988. The number in brackets is days after stocking.





Appendix 14. Percent frequency of occurence of various food items in walleye stomach contents per sample period, from Glaslyn and Shore Ponds, 1988. The number in brackets is days after stocking.

Appendix 15. Total length and weight of walleye raised in Saskatchewan Rearing Ponds, 1988. Sample size in brackets.

Pond	Date Sampled	Days In Pond	Total Length Mean ± SD (mm)	Mean Weight (g)	Sample Size
Codette	7 June 88	11	17.0 ± 1.12	0.052	75
	15	19	26.2 ± 2.77	0.185	61
	21	25	36.3 ± 4.45	0.455	68
	27	31	46.8 ± 4.81	0.940	55
	6 July 88	40	53.2 ± 5.03	1.345	61
	13	47	61.1 ± 6.05	1.940	62
	5 Aug 88	70	71.9 ± 9.91	2.911	49
Jackfish	9 June 88	15	18.6 ± 1.06	0.063	61
	16	22	26.1 ± 1.25	0.157	58
	22	30	34.6 ± 1.66	0.433	64
	30	38	44.1 ± 3.27	0.738	56
	7 July 88	45	50.3 ± 3.81	1.036	56
	18	56	58.6 ± 4.27	1.712	47
Meadow 1	9 June 88	15	16.5 ± 1.30	0.050	69
	16	22	21.8 ± 1.88	0.115	66
	22	30	30.8 ± 3.65	0.304	80
	29	37	38.1 ± 5.09	0.538	36
	7 July 88	45	49.2 ± 3.50	1.055	61
	23	61	67.3 ± 4.96	2.594	56
Meadow 2	9 June 88	15	19.6 ± 3.19	0.069	53
	16	22	26.3 ± 1.32	0.192	75
	22	30	34.9 ± 2.36	0.442	64
	29	37	41.7 ± 3.87	0.721	60
	7 July 88	45	49.4 ± 6.66	1.201	61
	23	61	61.3 ± 6.44	2.483	48
Glaslyn	8 June 88	14	14.3 ± 0.76	0.032	3
	16	22	20.9 ± 2.56	0.098	7
	21	27	27.2 ± 3.11	0.204	56
	30	36	40.1 ± 3.71	0.637	9
	20 July 88	56	66.2 ± 6.04	2.663	48
Shore	29 June 88	33	38.7 ± 2.40	0.526	63
	24 Aug 88	89	71.9 ± 10.07	3.190	49

Appendix 16. Suitability index (SI) ratings for the rearing ponds, 1988. Values are determined from the SI graphs in section 2.8.2.

	Suitability Index (SI) Rating					
Variable	Codette	Jackfish	Meadow 1	Meadow 2	Glaslyn	Shore
V_1	1.00	0.92	1.00	0.75	0.82	0.80
V_2	0.61	0.40	0.80	0.90	0.16	0.00
V_3	0.88	0.47	0.85	1.00	0.85	1.00
V_4	0.90	0.90	0.95	0.90	0.90	0.36
V_5	1.00	0.80	0.76	0.89	1.00	1.00
V_6	1.00	0.95	1.00	1.00	1.00	1.00
V_7	1.00	0.76	0.98	0.95	0.42	0.00
V_8	1.00	1.00	1.00	1.00	1.00	1.00
V_9	1.00	1.00	1.00	1.00	0.75	0.45

Variable	Definition
V_1	Average transparency (Secchi depth) during summer.
V_2	Mean weekly usable zooplankton concentration during pond culture.
V_3	Percent of waterbody with cover during culture period.
V_4	Least suitable pH during the year.
V_5	Minimum DO level above thermocline in summer.
V_6	Minimum DO at surface during summer.
V_7	Mean weekly un-ionized ammonia concentration during culture period.
V_8	Mean weekly surface water temperature during spring and summer.
V_9	Trophic status of pond.